FTD-HT-23-1496-68

AD694430

FOREIGN TECHNOLOGY DIVISION

ALL UNION CONGRESS ON CHEMISTRY AND THE APPLICATION OF ADDITIVES TO LUBRICANTS AND FUELS

(Selected Articles)

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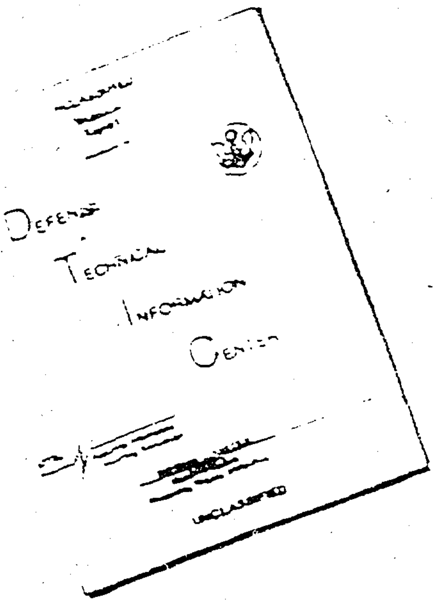

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EDITED TRANSLATION

ALL UNION CONGRESS ON CHEMISTRY AND THE APPLICATION OF ADDITIVES TO LUBRICANTS AND FUELS

(Selected Articles)

English pages: 122

SOURCE: Vsesoyuznoye Soveshchaniye po Khimii i Primeneniyu Prisadok K Maslam i Toplivam 2D, 1966, Prisadki K Maslam, Trudy (All Union Congress on Chemistry and the Application of Additives to Lubricants and Fuels). 2nd Report, 1966 Additives to Lubricants. Transactions. 1966, pp. 148-157, 281-324, 336-341, 370-388.

Translated Under: Contract F33657-68-D-0866 P002

DATA HANDLING PAGE

- **01-ACCESSION NO.:** TT9000907
- **98-DOCUMENT LOC:**
- **39-TOPIC TAGS:** lubricant additive, lubricating oil, corrosion inhibitor, antifriction material, mineral oil, nitration
- **09-TITLE:** CORROSION-INHIBITOR ADDITIVES AND PRESERVATIVE RUNNING OILS BASES ON THEM
- **47-SUBJECT AREA:** 07, 11
- **42-AUTHOR CO-AUTHORS:** KREYN, S. E.;16-SHEKHTER, YU. N.;16-LEVITIN M. K.;16-VILENKIN, A. V.;16-KALASHNIKOV, V. P.
- **10-DATE OF INFO:** -----66
- **43-SOURCE:** VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAN 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- **68-DOCUMENT NO.:** FTD-HT-23-1496-68
- **69-PROJECT NO.:** 73201-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASH
UNCL, 0	NONE	UNCL

76-REEL FRAME NO	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0532			UR	15

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-AT7021012	94-00	TRANSLATION	NONE

- **STEP NO.:** 02-UR/0000/66/000/000/0148/0157
- **ACCESSION NO.:**

ABSTRACT

(U) The purpose of this investigation was to improve the antifriction and corrosion inhibiting properties of automotive lubricating oils. The experiments involved nitration of mineral oils. On the basis of these experiments an oil additive AKOR-1, and technical production methods for this additive were developed. AKOR-1 improves the corrosion inhibiting properties of motor and transmission oils with respect to cast iron and nonferrous metals. AKOR-1 improves only the anticorrosive and cleaning properties of oils, while the other properties of the oils remain the same. AKOR-1 added in 10 percent concentration to motor and lubricating oils successfully passed practical field tests in the internal combustion engines OD-9, 2Ch-8, 5/11, GAZ-69, and YaAZ-238 and in trucks GAZ-51, ZIL157, and KRAZ-214. Orig. art. has: 2 formulas, 2 figures, and 6 tables.

DATA HANDLING PAGE

- **01-ACCESSION NO.:** TT9000908
- **98-DOCUMENT LOC:**
- **39-TOPIC TAGS:** lubricant, lubricant property, lubricant additive, lubricant component
- **09-TITLE:** OPERATING EXPERIENCE WITH ZIL-130 ENGINES USING AS-8 OIL WITH VNII NP-360 ADDITIVE
- **47-SUBJECT AREA:** 11, 13
- **42-AUTHOR CO-AUTHORS:** OBLEUKHOVA, O. S.;16-PROTASOV, V. V.;16-KISELEVA, T. T.;16-BURTSEVA, G. V.
- **10-DATE OF INFO:** -----66
- **43-SOURCE:** VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- **68-DOCUMENT NO.:** FTD-HT-23-1496-68
- **69-PROJECT NO.:** 73201-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASH
UNCL, 0	NONE	UNCL

76-REEL FRAME NO	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0533			UR	7

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-AT7021032	94-00	TRANSLATION	NONE

- **STEP NO.:** 02-UR/0000/66/000/000/0281/0286
- **ACCESSION NO.:**

ABSTRACT

(U) The performance of the high rpm ZIL-130 engine, running on AS-8 lubricating oil with VNII NP-360 additive was tested in a fleet of 70 motor vehicles operating under various climatic conditions. The purpose of the study was to examine the lubricating properties of an oil prepared according to standard [illegible] 10541-63. The study involved visual examination of the various engine parts in order to assess the detergent-, antio[illegible]ive-, anticorrosion-, and low temperature properties of the lubricating oil. In addition, micrometric measurements were made to determine the oil's anti-wear property and the chemical analysis of the used oil was employed for determining the oil's deterioration. The tests (200,000 kilometers) revealed that the AS-8 oil with VNII NP-360 additive increases the wear resistance of the parts of the ZIL-130 engine. Orig. art. has: [illegible] figures, 3 tables.

DATA HANDLING PAGE

01-ACCESSION NO.: TT9000909

98-DOCUMENT LOC:

39-TOPIC TAGS: lubricant additive, lubricant property, lubricating oil, diesel engine

09-TITLE: TEST RESULTS FOR OILS WITH ADDITIVES USED IN THE YaMZ-238NB ENGINE

47-SUBJECT AREA: 11, 13

42-AUTHOR CO-AUTHORS: SIGAL, N. I.;16-SLAROV, YE. P.;16-YEFREMOV, V. N.;16-GUSEV, G. M.;16-BELYANCHIKOV, G. P.

10-DATE OF INFO: -----66

43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)

68-DOCUMENT NO.: FTD-HT-23-1496-68

69-PROJECT NO.: 72301-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASH
UNCL, 0	NONE	UNCL

76-REEL FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0534			UR	7

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-AT7021033	94-00	TRANSLATION	NONE

STEP NO.: 02-UR/0000/66/000/000/0286/0290

ACCESSION NO.:

ABSTRACT

(U) The performance of several batches of lubricating oils with various additives were tested in a new four-stroke diesel engine (YaMZ-238NB) developed by the Yaroslav Engine Plant (Yaroslavskiy motornyy zavod). The oils were evaluated on a standarized stationary engine run at different rpm's (1300-1700) for various periods (10-210 minutes) under different loads. The results of the tests were found to be very inconclusive because of the variation in the properties of the base oil in various batches. However, the best performance in the YaMZ-238NB engine was exhibited by Series 1 oil supplemented with 5 percent VNII NP-370, 2 percent PMS'Ya, 0.5 percent LZ-23k, and 0.005 percent PMS-200A additives. Orig. art. has: 6 figures, 3 tables.

DATA HANDLING PAGE

01-ACCESSION NO.: TT9000910

98-DOCUMENT LOC:

39-TOPIC TAGS: lubricating oil, lubricant property, lubricant additive, antiwear additive

09-TITLE: EFFECTIVENESS OF USING ADDITIVES IN HYDRAULIC-COUPLING OILS FOR PASSENGER AUTOMOBILES

47-SUBJECT AREA: 11, 13

42-AUTHOR CO-AUTHORS: OBLEUKHOVA, O. S.;16-KRYUCHESHNIKOVA, K. N.

10-DATE OF INFO: -----66

43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)

68-DOCUMENT NO.: FTD-HT-23-1496-68

69-PROJECT NO.: 72301-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASH
UNCL, 0	NONE	UNCL

76-REEL FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0535			UR	10

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-AT7021034	94-00	TRANSLATION	NONE

STEP NO.: 02-UR/0000/66/000/000/0291/0296

ACCESSION NO.:

ABSTRACT

(U) Several additives (MASK, DF-11, PMS-200A) were examined for improvement of the characteristics of VNII NP-1 transmission oil for passenger cars. The tests were based on visual examination of the different parts of automobiles operating for various distances (up to 100,000 kilometers) under various load conditions and ambient temperatures (minus 60 degrees to plus 130 degrees C). The best oil performance (2-3 times longer service) resulted from supplementing the VNII NP-1 transmission oil base with 4 percent of MASK, 2.2 percent of DF-11, and 0.005 percent of PMS-200A additives. The presently marketed transmission oil (VNII NP-1) contains DF-1 additive (phenyl-alpha-naphthyl amine) and its antiwear, antioxidative, and anticorrosive properties are considered unsatisfactory. Orig. art. has: 4 figures, 1 table.

DATA HANDLING PAGE

- 01-ACCESSION NO.: TT9000911
- 98-DOCUMENT LOC:
- 39-TOPIC TAGS: lubricant additive, lubricant property, lubricating oil, diesel engine
- 09-TITLE: COMBINATION OF ASH-FORMIN AND POLYMERIC ASH-FREE ADDITIVES IN MOTOR OILS AS A WAY TO FURTHER QUALITY IMPROVEMENT
- 47-SUBJECT AREA: 11, 13
- 42-AUTHOR/CO-AUTHORS: SEMENIDO, YE. G.;16-TRAKTOVENKO, I. A.;16-SHCHEGOLEV, N. V.;16-SENICHKIN, M. A.;16-LOZAR', A.S.
- 10-DATE OF INFO: -----66
- 43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- 68-DOCUMENT NO.: FTD-HT-23-149-68
- 69-PROJECT NO.: 72301-78
- 63-SECURITY AND DOWNGRADING INFORMATION: UNCL, 0
- 64-CONTROL MARKINGS: NONE
- 97-HEADER CLASH: UNCL
- 76-REEL FRAME NO.: 1889 0536
- 77-SUPERSEDES:
- 78-CHANGES:
- 40-GEOGRAPHICAL AREA: UR
- NO OF PAGES: 7
- CONTRACT NO.: F33657-68-D-0866 P002
- X REF ACC. NO.: 65-AT7021035
- PUBLISHING DATE: 94-00
- TYPE PRODUCT: TRANSLATION
- REVISION FREQ: NONE
- STEP NO.: 02-UR/0000/66/000/000/0297/0300
- ACCESSION NO.:

ABSTRACT

(U) Several compositions of base lubricating oil with ash-free resinous additives (SB-3, DF-11, VN-18) and ash-containing additives (SK-11, DS-11, VNII NP-360) were tested in a YaMZ-236 diesel engine using a 150 hour test duration. The tests involved inspection of engine parts for the extent of wearout, examination of oil composition, and piston tolerance. In general, the additive containing oils showed superior performance as compared with the pure base oil. Orig. art. has: 4 figures, 4 table .

DATA HANDLING PAGE

- 01-ACCESSION NO.: TT9000912
- 98-DOCUMENT LOC:
- 39-TOPIC TAGS: lubricating oil, lubricant property, lubricant additive
- 09-TITLE: SELECTION OF OPTIMUM ADDITIVE COMBINATIONS FOR MOTOR OILS ON A BENCH WITH A SINGLE-CYLINDER AIR-COOLED ENGINE
- 47-SUBJECT AREA: 11, 13
- 42-AUTHOR/CO-AUTHORS: FILIPPOV, V. F. ; 16-GUBAREV, S. M.
- 10-DATE OF INFO: -----66
- 43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- 68-DOCUMENT NO.: FTD-HT-23-1496-68
- 69-PROJECT NO.: 72301-78
- 63-SECURITY AND DOWNGRADING INFORMATION: UNCL, 0
- 64-CONTROL MARKINGS: NONE
- 97-HEADER CLASH: UNCL
- 76-REEL FRAME NO.: 1889 0537
- 77-SUPERSEDES:
- 78-CHANGES:
- 40-GEOGRAPHICAL AREA: UR
- NO OF PAGES: 14
- CONTRACT NO.: F33657-68-D-0366 P002
- X REF ACC. NO.: 65-AT7021036
- PUBLISHING DATE: 94-00
- TYPE PRODUCT: TRANSLATION
- REVISION FREQ: NONE
- STEP NO.: 02-UR/0000/66/000/000/0301/0309
- ACCESSION NO.:

ABSTRACT

(U) A new testing unit for lubricating oils was developed for rapid (10 hour) evaluation of oil quality, and grade. The unit based on a one-cylinder Ul'yanovets Model UD-1 air-cooled engine is described in detail. The method, called IDM-10FG, makes it possible to assess rapidly the composition of a given lubricating oil, to classify it according to the Premium, Heavy Duty, or Series 1 nomenclature, and to define optimum contents of various additives. Tables of recommended additive compositions were compiled from the test results. Oils of these compositions were then tested on a full-scale Moskvich-407 automobile engine. Orig. art. has: 5 tables.

DATA HANDLING PAGE

01-ACCESSION NO.	TT9000913
98-DOCUMENT LOC	
39-TOPIC TAGS	lubricant property, lubricating oil, test method
09-TITLE	TESTS OF SOVIET AND FOREIGN MOTOR OILS IN THE UIM-6-NATI AND UIM-6N-NATI SINGLE-CYLINDER BENCH INSTALLATIONS
47-SUBJECT AREA	11, 13
42-AUTHOR/CO-AUTHORS	ARABYAN, S. G.;16-BELYANCHIKOV, G. P.;16-DANILOV, I. N.;16-KHANLAROV, T.;16-KHOLOMONOV, I. A.
10-DATE OF INFO	-----66
43-SOURCE	VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
68-DOCUMENT NO.	FTD-HT-23-1496-68
69-PROJECT NO.	72301-78
63-SECURITY AND DOWNGRADING INFORMATION	UNCL, 0
64-CONTROL MARKINGS	NONE
97-HEADER CLASH	UNCL
76-REEL FRAME NO.	1889 0538
77-SUPERSEDES	
78-CHANGES	
40-GEOGRAPHICAL AREA	UR
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PUBLISHING DATE	94-00
TYPE PRODUCT	TRANSLATION
REVISION FREQ	NONE
STEP NO.	02-UR/0000/66/000/000/0310/0319
ACCESSION NO.	

ABSTRACT

(U) A mineral lubricating oil testing unit (the UIM-6-NATI) based on a one-cylinder engine and a modification of it (the UIM-6N-NATI) are described in detail. A reliable, short (120 hr) testing procedure is described for rapid differentiation among the oils: heavy duty, Series 1, and Series 2. A large number of domestic and foreign oils of various quality were examined on these units and the results of these examinations were found to agree well with the actual quality of the oils as well as with the results of the old-style 500-800 hr tests. Orig. art. has: 1 figure, 7 tables.

DATA HANDLING PAGE

01-ACCESSION NO.	TT9000914
98-DOCUMENT LOC	
39-TOPIC TAGS	lubricant additive, lubricating oil, test method
09-TITLE	OIL AND OIL-ADDITIVE SELECTION AND USE-PROPERTY MOTOR RATING FOR TWO-STROKE GASOLINE ENGINES
47-SUBJECT AREA	11, 21
42-AUTHOR/CO-AUTHORS	FILIPPOV, V. F.;16-BUKOLOV, V. M.; 16-GAVRYUKHIN, V. M.
10-DATE OF INFO	-----66
43-SOURCE	VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
68-DOCUMENT NO.	FTD HT-23-1496-68
69-PROJECT NO.	72301-78
63-SECURITY AND DOWNGRADING INFORMATION	UNCL, 0
64-CONTROL MARKINGS	NONE
97-HEADER CLASH	UNCL
76-REEL FRAME NO.	1889 0539
77-SUPERSEDES	
78-CHANGES	
40-GEOGRAPHICAL AREA	UR
NO OF PAGES	10
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PUBLISHING DATE	94-00
TYPE PRODUCT	TRANSLATION
REVISION FREQ	NONE
STEP NO.	02-UR/0000/66/000/000/0319/0324
ACCESSION NO.	

ABSTRACT

(U) A new versatile method (cylinder temperature 170-230 degrees C, maximum temperature of base oil 180-200 degrees C, maximum temperature of additive-containing oil 230 degrees C) of testing lubricating oils is described. The method's reliability is assessed on the reproducibility of the solid matter within plus or minus 10 percent. The method is recommended for use in making up lubricating oils, for research purposes, and for setting industrial standards for lubricating oils. Orig. art. has: 2 figures, 2 tables.

DATA HANDLING PAGE

01-ACCESSION NO.: TT9000915

98-DOCUMENT LOC:

39-TOPIC TAGS: lubricant additive, lubricant property, antioxidant additive, stabilizer additive, filtration

09-TITLE: IN-STORAGE PROPERTY CHANGES OF OILS OF VARIOUS CLASSES AND DETERMINATION OF THEIR PURITY

47-SUBJECT AREA: 11

42-AUTHOR/CO-AUTHORS: PAPOK, K. K. ; 16-ZUSEVA, B. S.

10-DATE OF INFO: -----66

43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)

68-DOCUMENT NO.: FTD-HT-23-1496-68

69-PROJECT NO.: 72301-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASN
UNCL, O	NONE	UNCL

76-REEL FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0540			UR	9

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-BC8010962	94-00	TRANSLATION	NONE

STEP NO.: 02-UR/0000/66/000/000/0336/0341

ACCESSION NO.:

ABSTRACT

(U) The samples of oils contg. additives made abroad and in the U.S.S.R. were prepd. in the lab. or in a pilot plant and the changes of their thermal oxidn. stability and of detergent potential during storage were measured. After 31 months, all the samples with foreign additives retained their initial thermal stability and after 45 months, the stability was maintained in 50 percent of the samples. The detergent potential did not change after 45 months except for premium and heavy duty oils with Ca additives where detergent potential was reduced after 31 months. The samples prepd. in the lab. had better properties than oils prepd. in the pilot plant. The thermal oxidn. stability of oil contg. Soviet additives did not change in 18 months and after 32 months it was reduced from 65-89 min. to 8-20 min. The detergent potential of heavy duty and Series 1 oils did not change after 32 months, while that of oils of Series 2 and Series 3 was lowered after 18 months to 20-55 units and after 32 months it was zero. The purity of oils and additives was characterized by the following method: 5 g. of oil or 1 g. of additive was dild. with 45 or 49 ml. of gasoline and the soln. was filtered through a biol. filter no. 4 of diam. 27 mm. by using a vacuum of 20-30 mm. After every 5 min. of filtration, a new filter was installed.

AFSC FORM AUG 66 4 (FTD OVERPRINT, DEC 66) k

DATA HANDLING PAGE

01-ACCESSION NO.: TT9000916

98-DOCUMENT LOC:

39-TOPIC TAGS: antioxidant additive, lubricant, phenyl compound

09-TITLE: USE OF PAIRED ANTIOXIDANTS FOR TURBINE OILS

47-SUBJECT AREA: 11

42-AUTHOR/CO-AUTHORS: IVANOV, K. I.; 16-VILYANSKAYA, YE. D.; 16-LUZHETSKIY, A. A.; 16-ALEKSANDROV, A. N.

10-DATE OF INFO: -----66

43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)

68-DOCUMENT NO.: FTD-HT-23-1496-68

69-PROJECT NO.: 72301-78

63-SECURITY AND DOWNGRADING INFORMATION	64-CONTROL MARKINGS	97-HEADER CLASN
UNCL, O	NONE	UNCL

76-REEL FRAME NO.	77-SUPERSEDES	78-CHANGES	40-GEOGRAPHICAL AREA	NO OF PAGES
1889 0541			UR	6

CONTRACT NO.	X REF ACC. NO.	PUBLISHING DATE	TYPE PRODUCT	REVISION FREQ
F33657-68-D-0866 P002	65-AT7021046	94-00	TRANSLATION	NONE

STEP NO.: 02-UR/0000/66/000/000/0370/0373

ACCESSION NO.:

ABSTRACT

(U) A study was made to determine the synergistic antioxidative effectiveness of pairs of compounds from beta-naphthole and phenyl-beta-naphthylamine compounds. The synergistic effect was established in laboratory tests with turbine oils containing pairs of additives (coded) from these two groups of compounds and excellent agreement was found with the results of the actual performance of the oils in turbines. The factors underlying the synergistic effect could not be established in this study. Orig. art. has: 3 figures, 1 table.

AFSC FORM AUG 66 4 (FTD OVERPRINT, DEC 66) l

DATA HANDLING PAGE

- 01-ACCESSION NO.: TT9000917
- 98-DOCUMENT LOC:
- 39-TOPIC TAGS: lubricant passivator, transformer oil, antioxidant additive
- 09-TITLE: ADDITIVE MIXES FOR STABILIZATION OF TRANSFORMER OILS
- 47-SUBJECT AREA: 11
- 42-AUTHOR/CO-AUTHORS: SHAKHNOVICH, M. I.
- 10-DATE OF INFO: -----66
- 43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM I TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- 68-DOCUMENT NO.: FTD-HT-23-1496-68
- 69-PROJECT NO.: 72301-78
- 63-SECURITY AND DOWNGRADING INFORMATION: UNCL, 0
- 64-CONTROL MARKINGS: NONE
- 97-HEADER CLASN: UNCL
- 76-REEL FRAME NO.: 1889 0542
- 77-SUPERSEDES:
- 78-CHANGES:
- 40-GEOGRAPHICAL AREA: UR
- NO OF PAGES: 9
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- PUBLISHING DATE: 94-00
- TYPE PRODUCT: TRANSLATION
- REVISION FREQ: NONE
- STEP NO.: 02-UR/0000/66/000/000/0374/0378
- ACCESSION NO.:

ABSTRACT

(U) The effectiveness of disalicylideneethylenediamine (deactivator), anthranilic acid (passivator), and phenyl-beta-naphthylamine and 2,6-di-tertiary-butyl-4-methyl phenol (antioxidants) and their combinations in the stabilization of transformer oils was studied under static laboratory conditions (44 hr oxidation with oxygen in the presence of copper and iron at 100 degrees C and 49 kilovolt per centimeter potential difference). Excellent stabilization of the transformer oils was achieved by compositions containing 0.05 wt percent anthranilic acid and 0.05-0.2 wt percent antioxidant additives. Orig. art. has: 3 figures, 1 table.

DATA HANDLING PAGE

- 01-ACCESSION NO.: TT9000918
- 98-DOCUMENT LOC:
- 39-TOPIC TAGS: titrimetry, lubricant additive, lubricating oil
- 09-TITLE: INVESTIGATION OF ADDITIVES AND ADDITIVE OILS BY A POTENTIOMETRIC METHOD
- 47-SUBJECT AREA: 11
- 42-AUTHOR/CO-AUTHORS: LUNEVA, V. S.; 16-BURDENYUK, L. N.
- 10-DATE OF INFO: -----66
- 43-SOURCE: VSESOYUZNOYE SOVESHCHANIYE PO KHIMII I PRIMENENIYU PRISADOK K MASLAM K TOPLIVAM 2D, 1966, PRISADKI K MASLAM. TRUDY (RUSSIAN)
- 68-DOCUMENT NO.: FTD-HT-23-1496-68
- 69-PROJECT NO.: 72301-78
- 63-SECURITY AND DOWNGRADING INFORMATION: UNCL, 0
- 64-CONTROL MARKINGS: NONE
- 97-HEADER CLASN: UNCL
- 76-REEL FRAME NO.: 1889 0543
- 77-SUPERSEDES:
- 78-CHANGES:
- 40-GEOGRAPHICAL AREA: UR
- NO OF PAGES: 13
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- X REF ACC. NO.: 65-AT7021048
- PUBLISHING DATE: 94-00
- TYPE PRODUCT: TRANSLATION
- REVISION FREQ: NONE
- STEP NO.: 02-UR/0000/66/000/000/0379/0388
- ACCESSION NO.:

ABSTRACT

(U) The applicability of the potentiometric titration method (up to 520 mV at pH equals 10) for determining the deterioration (alkalinity, metal content, ash content) of additives in oils and additive oils was investigated. It was found that all oil and oil additive deterioration indices could be determined by the potentiometric titration technique with an accuracy as high as 0.02-0.25 percent. The study revealed that imported oils with additives have higher phosphorus and zinc content than the corresponding domestic oils. In general, the potentiometric method was rated very useful and reliable. Orig. art. has: 7 figures, 5 tables.

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CORROSION-INHIBITOR ADDITIVES AND PRESERVATIVE RUNNING OILS BASED ON THEM

S.E. Kreyn, Yu.N. Shekhter, M.M. Levitin, A.V. Vilenkin, V.P. Kalashnikov, A.L. Dol'berg, V.I. Goryacheva, L.D. Khoroshilova, and K.I. Bessmertnyy

Tractor-operating experience has shown that engine and transmission parts are subject to rusting during operation and storage under the influence of moisture and acid products that have entered the lubricating oil or been formed in it. Since the commercially available motor and transmission oils have unsatisfactory protective (antirust) properties [1], and liquid preservative oils of types K-17, NG-203 etc. have unsatisfactory operational properties [1, 2], there is a need for development of preservative running oils that combine high protective and use properties. For this purpose, special additives that act as corrosion inhibitors must be added to the existing commercial oils in addition to the additives that improve operational properties. Use of preservative running-lubricating oils will lengthen the service lives of motor-tractor equipment and ultimately save a substantial amount of money.

The recommended protective additives are oil-soluble corrosion inhibitors: the reaction product of thiophosphoric acids with quinoid compounds and other phosphorus-containing substances [3], various derivatives of amines [4], organic acids, their esters and salts [5], derivatives of sulfacids [6], nitrated products [7], etc.

It has been established by laboratory studies of the protective and use properties of oils with various corrosion inhibitors that effective inhibiting additives can be obtained from nitrated oils that have been subjected to special treatment. In developing a technology for production of these additives, it was first necessary to solve such problems as selection of the raw material for nitration and the nitrating agent, as well as finding the optimum conditions for nitration and final treatment of the product. Two basic reactions take place when mineral oils are nitrated:

nitration proper

$$RAr \xrightarrow{HNO_3} RArNO_2$$

oxidation

$$RAr \xrightarrow{HNO_3} RArCO_2H$$

where RAr are the alkylaromatic and naphthenoaromatic hydrocarbons of the oil.

Table 1. Physicochemical Properties of Nitrated Oils (Nitration with 60% Nitric Acid at 15–55°C for 4 h)

a Показатели	b Нитрованные масла					
	c веретенное 3	d АС-6,5	d АС-9,5	e ДС-8	e ДС-11	f МС-20
g Количество гудрона, образующегося при нитровании, % на масло	1,0	1,5		h Отсутствует		0,4
i Зольность, %	1,3	0,5	1,0	1,2	1,2	0,6
j Щелочность по индикатору, мг KOH/г:						
k фенолфталеину	3,6	3,6	9,5	3,8	4,3	l Нейтрально
m бромфенолсинему	9,5	4,2	30,8	10,1	7,1	9,9
n Вязкость при 100°C, сст	9,0	8,7	17,6	17,3	21,8	23,7
o Содержание азота, %	—	—	0,75	0,53	0,85	0,67

KEY: (a) indicators; (b) nitrated oils; (c) spindle 3; (d) AS-...; (e) DS-...; (f) MS-20; (g) amount of asphalt formed during nitration, % on oil; (h) none; (i) ash; (j) indicator alkalinity, mg of KOH/g; (k) phenolphthalein; (l) neutral; (m) bromphenol blue; (n) viscosity at 100°C, cst; (o) nitrogen content, %.

Various oxygen-containing compounds are obtained as a result of the oxidation reaction: acids, hydroxyacids, lactones, esters, etc., and they are capable of the following secondary reactions:

a) condensation (polymerization), extending to the formation of asphalt-like sludges;

b) nitration, since the oxygen-containing compounds of the oil nitrate considerably more readily than the initial oils (the latter are subject to nitration of previously oxidized oils).

The brown nitrogen-oxide NO_2, N_2O_4, NO) vapors evolved during the oxidation reaction in turn promote oxidation of the hydrocarbons. Thus the oxidation process of the oil may become autocatalytic if substantial amounts of nitrogen-oxide vapors are liberated.

It is known that polycyclic aromatic hydrocarbons with short side chains and tarry substances are oxidized preferentially in mineral oils, undergoing secondary condensation reactions with formation of asphalt-like products. For nitration, therefore, we selected oils from which these compounds had been removed by selective refining. Oils AS-9.5, DS-8 and DS-11 obtained from eastern petroleums gave the best results (Table 1).

The direction of the nitrating process and its degree of conversion can be regulated by applying various nitration methods to the mineral oils.

The following oil-nitrating processes were examined.

1. Nitration with nitric acid at various concentrations (from 10 to 98%), with various acid-to-oil proportions. The optimum nitrating formulas were found in each case: addition and standing times for the acid, nitrating temperature, etc. As the nitric acid concentration increases, the content of nitro compounds in the nitrated oil increases without any marked increase in the content of oxidized products. Nitration with weak acids intensifies the oxidation reaction.

2. Nitration with nitrating mixtures or sodium nitrate or nitrite in the presence of sulfuric acid. These methods enable us to nitrate oils with formation of mononitro compounds, minimizing the oil-oxidation reaction.

3. Nitration with catalysts. By the use of various catalysts, the process can be controlled either in the direction of nitration (sodium nitrite, acetic acid, zinc stearate) or in the direction of oxidation (mercury salts).

First, the combined nitration and oxidation products were extracted from the nitrated oils and then separated by a secondary gasoline extraction.

It was shown that the nitro compounds are those principally responsible for the high protective, detergent and other properties of the nitrated oils. The amounts of nitrogen in them, determined by a specially developed method (a modified Kjeldahl method) [8], indicate that mononitro compounds (nitrogen content 3.7–3.9%) are formed during nitration under normal conditions.

The nitro group is found attached to the benzol ring (or, more rarely, to the naphthenic nucleus), for the most part at the para-position with respect to the alkyl radical.

Although they are less effective than the nitrocompounds, oxygen-containing products accompanying them in certain proportions – approximately 0.5:1 – form synergistic mixtures that exhibit the highest protective properties. In nitration, therefore, it is not desirable to produce only nitro compounds, for example, by nitration with anhydrous nitrating mixtures.

AS-9.5 oil nitrated with 40% nitric acid at 60% concentration was chosen as the base for the oil and fuel corrosion-inhibiting additives. This oil contains 6–7% of nitro compounds and 4–5% of oxidation products.

After carrying out nitration and eliminating the spent nitric acid, the acidic nitrated oil (acid number 20 mg of KOH/g) must be rendered slightly alkaline with some sort of neutralizing agent. Salts of sodium, calcium, and magnesium, and especially those of lead and aluminum, showed good protective, detergent, and dispersing properties [9].

Alkalinized nitrated oils show high ash contents and excessive alkalinity, which indicates not only the presence of salts of the type $(RArCOO)_2Ca$ in the nitrated oil, but also that they contain a finely dispersed colloidal suspension of CaO–$Ca(OH)_2$ and perhaps also $CaCO_3$ stabilized by surface-active compounds.

Work was done to study the mechanism of action of the nitrated oils and the products based on them (NG-204 and NG-204u liquid lubricants and AKOR-1 corrosion-inhibiting additive). It was established that nitrated oils and products based on them sharply reduce the permeability of the oil films to moisture and vapor [9] and reduce (at a certain concentration, to zero) the surface tension at the oil-water and water-(adsorbed oil film) interfaces.

They increase the wetting angle of an oil drop on water and reduce the wetting angle of a water drop on the oil's surface. This is particularly conspicuous with the AKOR-1 additive, and for lead and aluminum salts of the nitrated oil, i.e., in the most effective corrosion inhibitors. The ability to displace water from the surface of the metal and block its passage through the hydrophobic adsorption films that form is of great practical importance, since it permits the use of nitrated oils to preserve wet surfaces, as well as in varnishes, primers, paints, watered fuels, etc.

Studies conducted in a special chamber by using electric current for external polarization of plates [1] indicated that sodium and calcium salts of nitrated oils showed distinctly the properties of oil-soluble anodic atmospheric-corrosion inhibitors, while the lead and aluminum salts are adsorbed on both the anodic and cathodic areas of the metal exposed to corrosion, and

the protection given these areas is of the screening type.

Two problems were posed in developing corrosion-inhibitor additives for the motor and transmission oils.

1. Development of a corrosion-inhibitor additive which, in addition to the base oils or oils containing a combination of additives, will endow these oils with high protective properties without any deterioration of their motor properties.

2. Creation of a multifunctional corrosion-inhibiting additive that would, on addition to the base oils, endow them with high protective properties and simultaneously improve their wetting and anticorrosion properties.

The nitrated oils themselves or their salts (sodium, calcium, or aluminum) may be used as additives of the first type. Nitrated oil will also be taken as a base for creation of multifunctional additives of the second type. However, acidic nitrated oils are alkalinized in the presence of special promotor additives to improve the detergent and dispersing properties of the additives.

Like the use of special technological devices (single fast evaporation of water, passage of carbon dioxide, etc.), the presence of promotors during alkalinizing results in a sharp increase in the ash figure and alkalinity of the oil solution of the additive and, as a consequence, improvement of its wetting properties.

Promotors that have been tested and are recommended by the authors include alkylphenols, arylamines, alcohols, synthetic fatty acids, hydroxyethylated products, and many other compounds.

After appropriate refinement, therefore, the following technology was adopted for production of AKOR-1 additive: selectively refined DS-8 or DS-11 oils are treated with 30% of 60% nitric acid, followed by addition of 10% stearic acid; the mixture is neutralized with 20% calcium oxide, heated to 120°C to eliminate water, and centrifuged. Two industrial batches of the additive were prepared by the above technology at a pilot plant at the "Neftegaz" refinery. The material balance of this process is given below.

Taken, %		Yield, %	
		Production of nitrated oil	
Mineral oil DS-8	100	Nitrated oil	103
		Volatile products	3
60% nitric acid	30	Spent nitric acid (30%)	20
Calcium oxide hydrate (100%)	3	Mechanical impurities	4
		Losses	3
TOTAL	133	TOTAL	133

Production of AKOR-1 Additive

Nitrated oil	100	AKOR-1 Additive	1[illegible]2
Stearic acid	10	Waste	28
Calcium oxide	20		
TOTAL	130	TOTAL	130

Several laboratory batches of the AKOR-1 additive were prepared substituting synthetic fatty acids for the stearic acid. It was established that the synthetic fatty acids combine well with the nitrated oil (Table 2) and that the resulting additives are highly effective (Table 3).

The configuration of the apparatus and the flow chart for AKOR-1 production at the "Neftegaz" refinery are examined below.

Mineral oil (Fig. 1) and nitric acid are fed continuously into reactor 1. Heat is liberated as a result of the nitration reaction and removed by cold water. The reaction mixture enters reactor 2, where the nitration reaction continues for another [illegible] h at 55°C. Then the mixture is directed into settling tanks 3 and 4. The spent acid drains by gravity into apparatus 5 and is reused for nitration. The acid nitrated oil goes into apparatus 6, where it is mixed with melted stearin (or synthetic fatty acids [SFA] (СЖК) and neutralized with calcium oxide hydrate. The product is then dehydrated in the system composed of heat exchanger 9 and column 10. The product flows from the bottom of column 10 into centrifuge 12, is heated in tank 14, and further purified on the ultracentrifuge 15, from which the final additive is run into the shipping containers.

Table 2. Physicochemical Properties of AKOR-1 Additive Obtained using Synthetic Fatty Acids

a	b			
	c	d	e	f
g				
h	5.6	5.0	5.5	4.9
i	12.5	10.0	10.2	7.5
j				
k	41.3	16.7	27.9	10.4
l	89.4	46.2	76.6	54.9
m	44.8	54.8	38.6	41.4

KEY: (a) indicator; (b) synthetic fatty acids used; (c) broad fraction from Mendeleyev plant; (d) $C_{1?}-C_{16}$ fraction from Shebekinsk combine; (e) $C_{1?}-C_{2?}$ fraction from Volgograd refinery; (f) $C_{2?}-C_{2?}$ fraction; (g) ash, %; (h) total; (i) sulfate; (j) indicator alkalinity, mg of KOH/g; (k) phenolphthalein; (l) bromphenol blue; (m) viscosity at 100°C, cst.

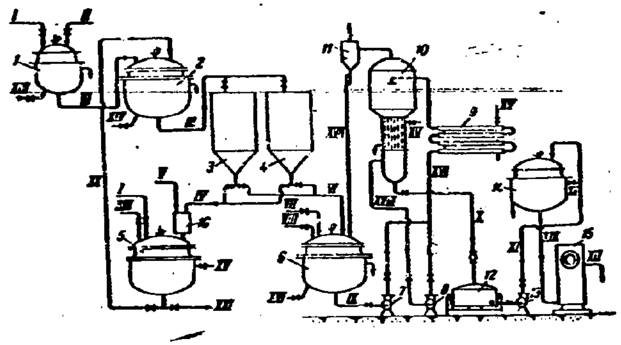

Fig. 1. AKOR-1 additive production flow. 1, 2) reactors; 3, 4) settling tanks; 5) apparatus for concentrating used nitric acid; 6) neutralizing mixer; 7) pump for delivery of product into heat exchanger; 8) circulating pump; 9) heat exchanger; 10) water-vaporizing column; 11) drop chamber; 12) centrifuge; 13) pump delivering product for final centrifuging; 14) intermediate pressure tank; 15) ultracentrifuge; 16) nitric-acid metering system. Lines: I) mineral oil; II) 60% nitric acid; III) oxygen-oil emulsion; IV; spent acid; V) 98% nitric acid; VI) nitro oil to neutralizing mixer; VII) molten stearin or SFA; VIII) milk of lime; IX) watery product; X) dried product for centrifuging; XI, XIX) product to final centrifuging; XII) AKOR-1 additive; XIII) cold water; XIV) hot water; XV) vapor; XVI, XVIII) dried circulating product; XVII) final product; XX) 60% nitric acid separated from spent acid; XXI) nitric-acid drainage.

The AKOR-1 protective additive produced by the described method has a comparatively high ash content (5-10%). We succeeded in reducing the ash content in the additive by lowering the calcium oxide hydrate concentration from 20 to 5%. Use of mixtures of calcium and sodium oxide hydrates in various proportions, or sodium oxide hydrate alone, to neutralize the acidic nitrated oil gave similar results. As Table 3 shows, AKOR-1 additive produced with SFA and sodium oxide hydrate shows lower ash content and 100°C viscosity level while retaining effective anticorrosion properties.

The laboratory studies also made it possible to establish that the viscosity of AKOR-1 additive can be lowered markedly and its purity increased if the final stage of purification in production is carried out in a gasoline solution. This complicates the technology slightly, since it is necessary to have

Table 3. Production of AKOR-1 Additive by Various Recipes

a (oil nitrated with 60% nitric acid, 30% on raw material)	b (additive, 10% on nitrated oil)	c (neutralizing agent)	d (amount of neutralizing agent, % on nitrated oil)	e (amount of deposits from purification, % on nitrated oil)
АС-9.5	Стеариновая кислота	Гидрат окиси кальция	5	—
АС-9.5	» »	Гидрат окиси натрия	1.5	25.2
АС-9.5	СЖК, фракция $C_{..}$—$C_{..}$	Гидрат окиси кальция	3	3.7
АС-9.5	» »	Гидрат окиси натрия	1.0	5.3
АС-9.5	СЖК, фракция $C_{..}$—$C_{..}$	То же	2.0	25.0
АС-9.5	» » »	»	[illegible]	5.0
АС-9.5	» » »	Гидрат окиси кальция	[illegible]	—
ДС-11	Стеариновая кислота	То же	[illegible]	
ДС-11	» »	Гидрат окиси натрия	1.5	23.2
ДС-11	» »	То же	3.0	4.9
ДС-11	» »	Гидрат окиси кальция	3.0	
ДС-11	СЖК фракция $C_{..}$—$C_{..}$	Гидрат окиси натрия	1.0	14.2
ДС-11	» » »	Гидрат окиси кальция	1.0	—
ДС-11	» » »	Гидрат окиси натрия	2.0	4.7
ДС-11	» » »	Гидрат окиси кальция	3.0	

(a) Oil nitrated with 60% nitric acid (30% on raw material)
(b) additive (10% on nitrated oil)
(c) neutralizing agent
(d) amount of neutralizing agent, % on nitrated oil
(e) amount of deposits from purification, % on nitrated oil
(f) properties of specimens of AKOR-1 additive obtained by the various recipes
(g) ash, %
(h) indicator alkalinity, mg of KOH/g
(i) phenolphthalein
(j) bromphenol blue

f Свойства образцов присадки АКОР-1, полученных по различной рецептуре					
g Зольность, %	h щелочность по индикаторам мг KOH/г		k вязкость при 100 °C сст	l растворимость в маслах	
	i фенолфталеину	j бромфенолвому синему		m 10% в МТ-16	n 10% в трансформаторном масле
3.8	2.3	46.7	26.1	14 суток (без осадка) r	14 суток (без осадка) r
0.8	−2.9	6.9	19.9	Сутки (осадок) t	26 суток (без осадка) r
3.4	6.6	55.0	39.3	50 суток (без осадка) r	50 суток (небольшой осадок) v
1.8	2.5	16.3	53.0	40 суток (без осадка) r	—
1.0	−5.3	18.4	14.1	Сутки (осадок) x	—
3.0	−1.2	46.9	31.8	40 суток (без осадка) r	—
4.0	0.9	49.9	41.1	14 суток (без осадка) r	14 суток (без осадка) r
1.0	−5.2	5.3	25.0	Сутки (осадок) x	27 суток (без осадка) r
3.75	2.5	52.7	58.5	78 суток (без осадка) r	36 суток (без осадка) r
1.7	4.1	11.7	28.0	23 суток (небольшой осадок) v	23 суток (небольшой осадок) v
4.5	1.7	54.3	122.3	16 суток без осадка r	
3.7	2.5	44.8	53.1	78 суток (без осадка) r	78 суток (небольшой белый осадок) z

(k) viscosity at 100°C, cst
(l) solubility in oils
(m) 10% in MT-16
(n) 10% in transformer oil
(o) AS-9.5
(p) stearic acid
(q) calcium oxide hydrate
(r) ...days (without deposit)
(s) sodium oxide hydrate
(t) one day (deposit)
(u) SFA, ...fraction
(v) ...days (small amount of deposit)
(w) same
(x) one day (deposit)
(y) DS-11
(z) 78 days (small amount of white deposit)

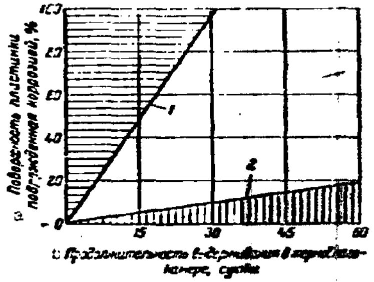

Fig. 2. Curves of time increase of corrosion damage to steel-plate surface (G-4 heat and humidity chamber, 7 h at 50°C, 17 h at 20°C; humidity 100%, plate material St. 3). 1) Commercial oils; 2) commercial oils + 10% AKOR-1.
KEY: (a) area of plate damaged by corrosion, %; (b) holding time in heat-and-humidity chamber, days.

an explosionproof apparatus and an additional installation for driving off the gasoline. However, the cost of building this apparatus is fully covered by the high quality of the resulting product, which is superior in a number of indicators to foreign additives used for similar purposes.

The protective properties of motor and transmission oils containing AKOR-1 additive in various concentrations were studied under laboratory conditions. For this purpose, metal plates – steel, cast iron, bronze, brass, copper, lead and other nonferrous metals – were coated with thin films of oil containing the additive and placed in water, in humidity chambers, or in chambers containing corrosive environments. In all cases, corrosion appeared on the plates much later than when the plates were protected with oils not containing additives [1, 10]. By way of example, Fig. 2 shows generalized time curves of the corrosion damage to steel plates in a heat-and-humidity chamber. When they were protected with commercial oils, the damage curve rises sharply, and plates coated with oils having better protective properties are completely corroded in no more than 30 days. The difference in the protective properties of the oils before and after addition of the various functional additives is illustrated by the width of the shaded region in Fig. 2. The increase in the area of the corrosion centers after addition of 10% of AKOR-1 additive to the oils is much slower, and no more than 20% of the plate area has been corroded after storage for two months in the chamber.

Table 4. Evaluation of Protective Properties of Oils in Exhaust-Gas Chamber (30 min at 50°C, 2 h at 20°C)

a	b					
	c		f		g	
	d	e	d	e	d	e
h ДСп-11	i	50	j	50	k	—
l ДСп-11 + 10% АКОР-1	m	0	n	20	m	0
МТ-16	i	70	o	50	p	50
q МТ-16 + 10% АКОР-1	m	0	n	20	m	0
r МТ-16п	s	100	p	70	k	—
t МТ-16п + 10% АКОР-1	m	0	n	10	m	0

KEY: (a) oil; (b) condition of nonferrous-metal plates after testing; (c) bronze; (d) surface condition; (e) amount of surface affected by corrosion, %; (f) brass; (g) aluminum; (h) DSp-11; (i) brown deposit; (j) reddish-brown point foci; (k) moderate darkening of entire surface; (l) DSp-11 + 10% AKOR-1; (m) no changes; (n) point foci barely discernible; (o) dark brown point foci; (p) dark point foci; (q) MT-16 + 10% AKOR-1; (r) MT-16p; (s) minute dark point foci; (t) MT-16p + 10% AKOR-1.

Table 4 presents certain data characterizing the protective properties of oils with the AKOR-1 additive for nonferrous metals.

The high protective properties of oils containing AKOR-1 additive have been confirmed by the results of storing automotive engines and transmissions on an outdoor platform (Table 5).

Certain physicochemical and operational properties of the oils undergo changes after introduction of AKOR-1 (Table 6).

Thus, the viscosity level of the oil at 100°C rises slightly and ash content increases. The detergent and anticorrosion properties of the oil are improved substantially. The protective additive has no noticeable detrimental effect on the quality indicators of the motor oils and transmission lubes.

Table 5. Surface Condition of Parts, Subassemblies and Units Prepared for Preservation with the Use of Various Commercial Oils with AKOR-1 Additive

a	b	c	d
e			
f	g 90% ДС-8 + 10% АКОР-1	h	i
j			
k	l 90% МТ-16п + 10% АКОР-1	m	m
n			
o	g 90% ДСп-8 + 10% АКОР-1	p	"
q			
r	l 90% МТ-16п + 10% АКОР-1	m	"
s			
t	u 90% АСп-9.5 + 10% АКОР-1	"	"
v			
r	w 90% нигрол + 10% АКОР-1	p	i
x			
y	z 90% ДС-8 + 10% АКОР-1	aa	m
	bb 90% АС-9.5 + 10% АКОР-1	19 месяцев (коррозии нет)	cc
m	l 90% МТ-16п + 10% АКОР-1	m	m
v			
r	l 90% МТ-16п + 10% АКОР-1	dd	ee
ff			
r	gg 90% ТАп-15 + 10% АКОР-1	p	m

KEY: (a) type designation and No. of machine; listing of preserved surfaces, units and assemblies; (b) oil; (c) storage time and condition of surfaces; (d) condition of oil film; presence of deposits and water; (e) Ural-375 motor vehicle, No. 5; (f) highly finished surfaces of engine cylinders, [Key continued on page 13]

[Key to Table 5, cont'd.] compressor, valves; (g) 90% DS-8 + 10% AKOR-1; (h) 21 months (no corrosion); (i) thin unbroken oil film; (j) transmission; (k) surfaces of gear teeth and shaft splines; (l) 90% MT-16p + 10% AKOR-1; (m) same; (n) YaAZ-206-A engine; (o) highly finished surfaces of engine cylinders, timing gear, compressor; (p) 19 months (no corrosion); (q) YaAZ transmission; (r) surfaces of gear teeth, shafts, guide rollers, shifting yokes and detents; (s) GAZ-51 engine; (t) honed cylinder surfaces; (u) 90% ASp-0.5 + 10% AKOR-1; (v) GAZ-51 transmission; (w) 90% nigrol + 10% AKOR-1; (x) GAZ-69 engine cylinder blocks; (y) honed surfaces, parting planes; (z) 90% DS-8 + 10% AKOR-1; (aa) 20 months (no corrosion); (bb) 90% AS-9.5 + 10% AKOR-1; (cc) unbroken oil film, streaks of oil on honed surfaces; (dd) 22 months (no corrosion); (ee) unbroken oil film; (ff) GAZ-69 transmission; (gg) 90% TAp-15 + 10% AKOR-1.

Table 6. Physicochemical and Operational Properties of DSp-11 Oil with 10% of AKOR-1 Additive

a Показатели	b Масло без присадки	c Присадка: d	e	f	g	h	i
j Вязкость, сст							
k при 100 °С	10.5	11.5	10.74	11.25	11.55	11.1	11.52
» 50 °С	60.3	69.0	61.2	66.2	68.2	65.4	—
l Зольность, %	0.26	0.86	0.60	0.36	0.37	0.55	0.53
m Температура, °С							
n вспышки	226	238	—	225	—	223	225
o застывания	−22	−23	−22	−22	−21	−21	−24
p Термоокислительная стабильность T_{250}, мин	36	33	31	30	29	27	25
q Моющий потенциал, %	20	—	50	45	45	38	30
r Моющие свойства на установке ПЗВ, баллы	1.5	0–0.5	0–0.5	0–0.5	0.5	0.5	0–0.5
s Нагарность при 400 °С, %	1.6	6.3	5.1	6.1	6.9	6.8	6.6
t Антикоррозионные свойства на установке ПЗЗ при 200 °С (свинец)	164	86	—	—	—	—	—

KEY: (a) indicator; (b) oil without additive; (c) additive; (d) nitrated DS-8 + 10% stearin + 10% $Ca(OH)_2$; (e) nitrated AS-9.5 + 10% stearin + 5% $Ca(OH)_2$; (f) nitrated AS-9.5 + 10% SFA (C_{20}–C_{30}) + 10% $Ca(OH)_2$; (g) nitrated AS-9.5 + 10% SFA (C_{20}–C_{30}) + 10% NaOH; (h) nitrated AS-9.5 + 10% SFA (C_{17}–C_{20}) + 5% $Ca(OH)_2$ + 5% NaOH; (i) nitrated AS-9.5 + 10% SFA (C_{10}–C_{16}) + + 3% $Ca(OH)_2$ + 2% NaOH; (j) viscosity, cst; (k) at; (l) ash; (m) temperatures, °C; (n) flash point; (o) pour point; (p) thermal-oxidation stability T_{250}, min; (q) potential detergency, %; [Key cont'd. on page 14]

[Key to Table 6, cont'd.] (r) Detergent power on PZV machine, points; (s) carbon scaling at 400°C; %; (t) anticorrosion properties on PZZ machine at 200°C (lead).

The running properties of motor oils with the AKOR-1 additive were checked during bench tests on OD-9 (a single-cylinder forced diesel), GAZ-69, YaAZ-238, 2Ch-8.5/11 and URAL-375 engines and use tests in GAZ-51, ZIL-157 and KRAZ-214 motor vehicles. It was reported in all cases that the engine parts remained cleaner and showed practically unchanged wear after addition of AKOR-1.

CONCLUSIONS

1. AKOR-1 protective additive was prepared from nitrated oils that had been treated with sodium or calcium oxide hydrates or mixtures thereof in the presence of stearic acid, SFA, and other compounds.

2. A flow chart for production of the additive was worked out and used.

3. AKOR-1 additive effectively improves the ability of commercial motor oils and transmission lubes to protect steel, cast-iron and nonferrous-metal parts from rusting.

4. The detergent and anticorrosion properties of oils with AKOR-1 additive are superior to those of oils without this additive, and other properties show virtually no differences.

5. In pure form or diluted with light oil, AKOR-1 additive can be used on a par with liquid preservative oils for internal preservation of mechanisms.

6. AKOR-1 additive, added to motor oils and transmission lubes in a concentration of 10%, has successfully passed use tests:

a) for protective properties when used to preserve engines and motor-vehicle tranmission assemblies during storage or an open-air platform for more than 20 months;

b) for operational properties in bench tests on OD-9, 2Ch-8.5/11, GAZ-69 and YaAZ-238 engines and use tests in GAZ-51, ZIL-157 and KRAZ-214 motor vehicles.

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OPERATING EXPERIENCE WITH ZIL-130 ENGINES USING AS-8 OIL WITH VNII NP-360 ADDITIVE

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DS-8 oil with VNII NP-360 additive [VNII NP: All-Union Scientific Research Institute of Oil and Gas Refining and Production of Synthetic Liquid Fuels], which had been recommended after long-term (600-hour) bench tests for V-type carbureted truck engines, was taken for extended road-use tests. Since 1964, this oil has been produced according to GOST 10541-63 under the type designation AS-8.

The tests were conducted with 70 vehicles in various climatic zones of the country (Crimea, Stavropol', Orel, Pskov) on a year-round basis, on hard-paved mountain and flatlands highways. Vehicles of the Crimea fleet were tested under routine operating conditions on the Yalta-Simferopol' and Yalta-Sevastopol' routes. The vehicles of the other fleets were run under routine operating conditions for 10-30% of the total mileage, and used for the remaining time in tire tests. The conditions of use are given in Table 1. A-76 gasoline was used in all fleets during the tests.

Plans called for replacing piston rings during the tests when oil burnoff had reached 0.8 liter/100 km and the bearing inserts when the oil pressure in the system had dropped to 1.9 kg/cm² at 1000 rev/min.

At the end of the tests, when the vehicles had accumulated 108-213 thousand km, these oil-consumption and -pressure limits

Table 1. Vehicle Operating Conditions

a	b	c				h	i		l
		d	e	f	g		j	k	
m Автоколонна № 1202, г. Ставрополь	22	340	—	59	41	4.0	n 55—65 (на асфальте, 40—55 (на горных и щебеночных);	90	700—750
o Автоколонна № 1120, г. Псков	21	350	—	78	22	4.0	p 51 (на асфальте), 40 (на гравии)	90	700—750
q Автоколонна № 1141, г. Орел	21	350	48	52	—	5.5	57—65 (на асфальте) r	100	700—750

Note: Servicing intervals: TO-1 every 1600-2000 km; TO-2 every 6000-8000 km [TO: Technical maintenance]. KEY: (a) fleet; (b) number of vehicles; (c) road characteristics; (d) length, km; (e) concrete, %; (f) asphalt, %; (g) traprock and gravel, %; (h) load, tons; (i) speed, km/h; (j) technical average; (j) top; (l) average daily mileage, km; (m) convoy No. 1202, Stavropol'; (n) 55-65 (on asphalt), 40-55 (on mountain and traprock roads); (o) convoy No. 1120, Pskov; (p) 51 (on asphalt), 40 (on gravel); (q) convoy number 1141, Orel; (r) 57-65 (on asphalt).

had not been reached. However, the bearing inserts of almost all vehicles were replaced after 100-150 thousand km in order to prolong crankshaft life.

Piston rings were replaced at mileages of less than 150 thousand km on only 13 engines of the Stavropol' fleet, in order to ensure full performance for the tire tests.

The following work was done at the end of the tests to rate the use properties of the oil:

a) visual inspection of engine parts to determine the detergent, antioxidant, anticorrosion and low-temperature properties of the oil;

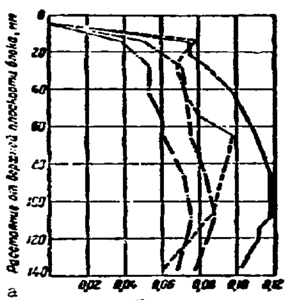
b) micrometer measurements on engine parts to determine antiwear properties;

c) analysis of the used oils, to permit determination of quality changes during use and adjustment of the recommended

oil-change intervals.

TEST RESULTS

Condition of engines. It was established on visual inspection to determine engine condition that AS-8 oil with VNII NP-360 additive has satisfactory detergent properties. Varnish on the cooled areas of the pistons came to 5-6 points on the PZV scale. The rest of the piston-skirt surface was coated with varnish ranging in color from yellow to dark reddish brown. No burning of the rings was observed on any of the engines inspected, and the combustion-chamber carbon deposits were insignificant. The anticorrosion properties of the oil were evaluated from the surface condition of the bearing-insert antifriction layer. There were no traces of corrosion damage on any of the inserts inspected, which indicates that the oil has satisfactory anticorrosion properties.



a

b

Fig. 1. Average value of maximum wear for four ZIL-130 engines after 135 thousand kilometers.
KEY: (a) distance from top plane of block, mm; (b) wear, mm.

The small amounts of gum on the engine parts and the insignificant amounts of low-temperature deposits (sludge) that were formed indicate that AS-8 oil has fully satisfactory antioxidant and low-temperature properties.

A highly important advantage of the VNII NP-360 additive established during the tests is that it shows little tendency to form barium-salt deposits on the engine's exhaust valves.

Engine wear. The antiwear properties of AS-8 oil with VNII NP-360 additive were determined by micrometer measurements on parts of 24 engines after 57-213 thousand kilometers.

Cylinder-sleeve wear after accumulation of up to 200 thousand km did not exceed 0.1 mm for most of the engines; here the average wear rate was 0.7 µ/1000 km, or considerably lower than in the ZIL-120 engine, which has a chromium-plated upper compression ring and whose cylinder sleeves wear at 4.5 µ/1000 km.

During the tests, the cylinder sleeves of the ZIL-130 engines showed comparatively uniform wear over their entire height (Fig. 1), an observation that can be explained by the favorable running conditions (long distances without stopping, high speeds, good roads), by the use of a Ni-Resist insert in the top of the sleeve, and by the good antiwear properties of the oil.

The effectiveness of using engine oils with high-quality multifunctional additives has also been affirmed by foreign investigators.

Thus, K. English [1] reports that when an engine was run on HD oil (which corresponds to AS-8 oil with the VNII NP-360 additive) at a coolant temperature of 80°C, sleeve and piston-ring wear is reduced by a factor of approximately 5 by comparison with the wear observed when the engine is run on plain oil (without additives).

Piston-ring-wear data for 11 engines are given below.

Engine mileage, thousands of km	Wear: mm (over total mileage)	Wear: μ (per 10 thousand km)
57-89	0.0029-0.020	0.5-2.5
108-147	0.020-0.128	1.3-9.8
150-213	0.021-0.100	1.4-4.7

Crankshaft wear was determined on the connecting-rod journals for 24 engines and on the main-bearing journals for 12 engines. The connecting-rod journals were measured with the engines partly and completely dismantled, and the main bearings only after full disassembly. The results of the micrometer measurements are given in Table 2.

Table 2. Main- and Connecting-Rod Journal Wear in ZIL-130 Engine

a Пробег, тыс. км	b Износ шеек, мм: c коренных: d минимальный	c коренных: e максимальный	c коренных: f средний	h шатунных: d минимальный	h шатунных: e максимальный	h шатунных: f средний
i До 100	—	—	—	0.000	0.007	0.003
До 150	0.010	0.090	0.020	0.000	0.009	0.005
До 200	[illegible]	0.066	0.037	0.000	0.011	0.003

KEY: (a) mileage, km; (b) journal wear, mm; (c) main bearing; (d) minimum; (e) maximum; (f) average; (h) connecting-rod bearing; (i) less than.

The wear of the connecting-rod bearing inserts at a vehicle mileage of 135 thousand km averaged 0.0065 mm, and the main-bearing insert wear 0.008 mm.

Over the indicated vehicle mileage, the average clearance between the crankshaft connecting-rod journal and the inserts with the connecting-rod assembled came to 0.073 mm, and 0.075 mm for the main bearings (the acceptable clearances for new engines are 0.026-0.065 mm).

The wear of other engine parts (connecting rod upper end, camshaft, valves, rockers, lifters, etc.) was insignificant, and it was unnecessary to replace these parts before 200 thousand km.

Oil consumption. As we know, oil consumption depends on a number of factors. K. Dzhordzhi [Georgi] [2] notes the following basic causes of increased oil consumption:

a) mechanical trouble — wear of piston-ring grooves and damage to the piston skirt; ring wear, loss of ring resiliency, seating of rings in grooves too tight or too loose; burning of the compression rings or plugging of slots in oil-control rings; wear, scoring or scratching of the honed cylinder surface, etc.;

b) operating conditions — high oil level, dilution of oil with fuel due to carburator maladjustment or low temperature in the engine's cooling system; driving speed;

c) oil quality — volatility, viscosity index, etc.

The above indicates how difficult it is to establish operating oil-consumption norms.

In these tests, oil consumption was recorded on the basis of the amounts drained at changes and the amounts added to replace burnoff during use.

The oil-burning rate changed insignificantly as a function of engine mileage. Thus, the average oil-burning rate was 0.3 liter/100 km up to 50 thousand km and 0.45 liter/100 km to 100 thousand km. For mileages up to 150 thousand km, oil consumption came to 0.35 liter/100 km, which is probably to be explained by piston-ring changes on some of the engines. The average consumption rate rose again to 0.4 liter/100 km as the vehicles accumulated 200 thousand km.

Control trips were taken periodically in all fleets to verify and adjust the specific oil-burnoff figures. Figure 2 shows average oil-burnoff values from control trips with nine vehicles that had accumulated 150-180 thousand kilometers. It follows from these data that as vehicle speed is increased from 45 to 75 km/h, the oil burnoff rate increases by a factor of 2, and by a factor of 4 when the speed is increased from 45 to 95 km/h.

The average oil-consumption figures indicated above are confirmed quite accurately by the data obtained in the control trips.

Table 3 presents over-all operating fuel- and oil-consumption figures. On the basis of these results, taking into consideration that normal vehicle operating conditions are different (short-haul runs, city traffic, extended or full-time trailer hauling, less highly qualified servicing), and the

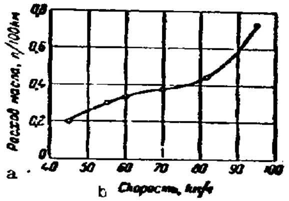


Fig. 2. Influence of vehicle speed on oil consumption.
KEY: (a) oil consumption, liters/100 km; (b) speed, km/h.

consequent higher consumption, we would recommend lowering the oil-consumption norms for the ZIL-130 engine to 2.5% of the amount of gasoline from 3.5%, which is the value presently in force for carburator engines.

Change in quality of oil and the oil-change interval. To establish rational oil-change intervals, oil specimens were taken for analysis during the tests. The analytical results showed that when the oil is changed at less than 8000 km, its 50°C viscosity has increased to 47 cst (vs. 42 for fresh oil). In some cases, fuel leakage into the crankcase during winter lowers the viscosity to 35 cst.

While the fresh oil contains no organic acids, its acid number rises to 0.44 mg of KOH/g.

The total mechanical-impurity content rises to 0.65%. This comparatively low figure indicates effectiveness of oil cleaning by the centrifugal final filter. The inorganic part of total impurities does not exceed 0.2%.

Table 3. Over-All Operational Fuel- and Oil-Consumption Figures

a Автохозяйство	b Фактический средний расход топлива л/100 км	c Расход масла при смене через 6000 км л/100 км: d смена	e долив: f средний	e долив: g максимальный	h Расход масла л/100 км: f средний	h: g максимальный	i Расход масла % на топливо: f средний	i: g максимальный
j Автоколонна № 1202, г. Ставрополь	45.2	0.13	0.44	0.52	0.57	0.65	1.26	1.44
k Автоколонна № 1120, г. Псков	36.8	0.13	0.48	0.54	0.61	0.67	1.66	1.82
l Автоколонна № 1141, г. Орел	35.4	0.13	0.39	0.45	0.52	0.58	1.47	1.64
m Автохозяйство «Ливадия», Крым	45.4	0.13	0.56	0.65	0.69	0.78	1.52	1.72

KEY: (a) fleet; (b) actual average fuel consumption, liters/100 km; (c) oil consumption with 6000-km changes, liters/100 km; (d) change; (e) added; (f) average; (g) maximum; (h) oil consumption, liters/100 km; (i) oil consumption, % on fuel; (j) convoy No. 1202, Stavropol'; (k) convoy No. 1120, Pskov; (l) convoy No. 1141, Orel; (m) "Livadiya" fleet, Crimea.

Analysis to determine the additive content in the oil indicated that the barium content had dropped by 35-40% and the zinc content by an average of 50%.

Thus, AS-8 oil with VNII NP-360 additive exhibits adequate antiwear, antioxidant and other operational properties and ensures dependable operation of ZIL-130 engines with the specified oil-change interval (every 4-8 thousand km) depending on operating conditions.

The results obtained on aging of the oil in the engines at long (up to 200 thousand km) mileages confirm the correctness of the recommended oil-change interval.

Conclusions

1. AS-8 oil with VNII NP-360 additive, produced according to GOST 10541-63, has operational indicators that meet the requirements of a heavily loaded high-speed ZIL-130 engine.

2. In operation on AS-8 oil with additives, the parts of ZIL-130 engines show satisfactory wearability after up to 200 thousand km.

3. The oil-consumption [norm] for ZIL-130 engines can be lowered to 2.5% (on the fuel).

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TEST RESULTS FOR OILS WITH ADDITIVES USED IN THE YaMZ-238NB ENGINE

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The Yaroslavl Engine Works has developed and put into production a new series of V-type, four-stroke diesels with outputs ranging from 180 to 520 hp, including supercharged versions. Use of the four-stroke cycle with compression ignition has made it possible to produce inexpensive engines with high wear resistance of their parts and good starting. The V-type cylinder arrangement is used as the basis for the small, compact powerplants. The engine designs provide for maximum interchangeability of parts and subassemblies. It was noted in elaboration of the designs and testing of the new engines on diesel oil with TsIATIM-339 [TsIATIM: Central Scientific Research Institute of Aviation Fuels and Lubricants] that this oil does not meet their requirements. It was therefore necessary to find oils for the four-stroke diesels, and especially for the supercharged models used in the K-700 tractors. Although satisfactory results had been obtained in preliminary tests of oil with the VNII NP-360 additive in the YaMZ-236 engine [YaMZ: Yaroslavl Engine Works], further experience in the operation of K-700 tractors with YaMZ-238NB engines showed that this oil does not ensure stable operation of the piston group.

An extensive battery of tests was carried out with the YaMZ-238NB engine (a four-stroke V-type eight-cylinder diesel with direct fuel injection) in order to establish quality requirements for the oils and select additives for the YaMZ engines

with consideration of the distinctive operating conditions of tractor diesels and the application of supercharging. The technical data of the engine are given below.

GOST designation	8Ч 13/14
Effective power N_e, hp	210
Crankshaft speed n, rev/min	1700
Cylinder bore, D, mm	130
Stroke S, mm	140
Number of cylinders i	8
Average effective pressure P_e, kg/cm^2	7.5
Average piston speed C_m, m/s	7.95
Displacement V_h, liters	14.86
Fuel consumption G_e, g/(ehph)	170
Oil capacity V, liters	32
Oil consumption, % on fuel	not above 2

The bench tests of the oils consisted of two stages — 240-hour short tests without changing the oil for preliminary evaluation and 800-hour extended tests with an oil change after 120 h.

The conditions of each test according to GOST 491-55 are given below.

Shaft speed, rev/min	1700	1300	1700	1700
Load, hp	none	180	210	none
Time, min	10	10	210	10

The indicators taken for evaluation were: quantity of deposits on piston-group parts, freedom of piston rings, piston-ring wear (based on weight loss), state of exhaust-valve seating surfaces, extent of clogging of centrifuge rotor chamber (RMTs reaction-type oil centrifuge), and the changes in the physicochemical properties of the oil, especially alkalinity. The degree of piston-group fouling was also determined by the point system.

Diesel fuel containing 1% sulfur was used in all tests. The base oil was DS-11. A list of the oils given short-term tests and the principal results are given in Table 1.

We may conclude from the data of Table 1 that all of the experimental additive oils ensure good piston-ring mobility, but differ substantially as regards their detergent and dispersing properties.

The poorest results as regards piston-group and centrifuge-rotor deposits were obtained in the tests of oil with 6 and 8% of VNII NP-360 additive.

Series 1 oils with the domestic additives ensure satisfactory cleanliness of the engine parts and appear to be substantially superior to VNII NP-360 additive.

Table 1. Results of Short-Term Oil Tests

a Продукты	b Условное обозначение масла	c Зольность масла, %	d Суммарная оценка нагарообразования на поршне, баллы	e Количество нагара на поршне и кольцах, г	f Износ верхнего кольца, г	g Отложения в РМЦ за период испытаний, г
h ДС-11 + 0,25% Сантолюб-493 + +4% Монто 513	i Серия 1	0.70	24.5	9.8	0.14	1250
j ДС-11 + 6% ВНИИ НП-360 + +0,003% ПМС-200А	k 6% ВНИИ НП-360	0.95	39.0	14.2	0.04*	2085
l ДС-11 + 8% ВНИИ НП-360 + +0,003% ПМС-200А	8% ВНИИ НП-360	1.25	37.5	16.2	0.06*	2450
m ДС-11 + 5% ВНИИ НП-370 + +2% ПМС'Я + 0,5% ЛЗ-23к + 0,005% ПМС-200А	5% ВНИИ НП-370	0.70	22.5	6.4	0.27	1035
n ДС-11 + 3% ЦИАТИМ-339 + +2% ПМС'Я + 0,003% ПМС-200А	o ЦИАТИМ-339 + +ПМС'Я	0.70	18.0	4.1	0.22	740
p ДС-11 + 3% БашНИИ-2 + 1% ПМС'Я + 0,005% ПМС-200А	q 3% БашНИИ-2	1.05	25.0	7.66	0.215	1060
r Д-11 + 5% БФК + 2% СБ-3 + +0,005% ПМС-200А	s 5% БФК	0.67	23.0	7.9	0.18	2700
t ДС-11 + 0.7% Сантолюб-493 + + 9% Монто-613	u Серия 2	1.50	21.5	9.0	0.22	1560
v ДС-11 + 11% ВНИИ НП-370 + +4% ПМС'Я + 0,05% ЛЗ-23к + 0,005% ПМС-200А	k 11% ВНИИ НП-370	1.50	24.0	9.4	0.23	1590
w ДС-11 + 3% АСК + 3% МАСК + 1,2% ДФ-11 + + 0,03% ПМС-200А	x АСК + МАСК	0.85	13.5	3.6	0.42	570
y Римула-30	y Римула	1.0	4.0	4.1	0.25	600

*Chromium-plated rings.
KEY: (a) products; (b) type designation of oil; (c) ash content of oil, %; (d) over-all scaling on piston, points; (e) amount of scale on piston and rings, g; (f) wear of top ring, g; (g) deposits in RMTs over test period, g; (h) DS-11 + 0.25% Santolube 493 + 4% Monto 613; (i) series 1; (j) DS-11 + 6% VNII NP-360 + + 0.003% PMS-200A; (k) 6%VNII NP-360; (l) DS-11 + 8% VNII NP-360 + 0.003% PMS-200A; (m) DS-11 + 5% VNII NP-370 + + 2% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (n) DS-11 + + 3% TsIATIM-339 + 2% PMS'Ya + 0.003% PMS-200A; (o) TsIATIM-339 + PMS'Ya; (p) DA-11 + 3%BashNII-3 + 1% PMS'Ya + 0.005% PMS-200A; (q)3% BashNII-2; (r) D-11 + + 5% BFK + 2% SB-3 + 0.005% PMS-200A; (s) 5% BFK; (t) DS-11 + 0.7% Santolube 493 + 9% Monto 613; (u) Series 2; (v) DS-11 + 11% VNII NP-370 + 4% PMS'Ya + 0.05% LZ-23k + + 0.005% PMS-200A; (w) DA-11 + 3% ASK + 3% MASK + 1.2% DF-11 + 0.03% PMS-200A; (x) ASK + MASK; (y) Rimula.

Series 2 oils with Monsanto additives, 11% VNII NP-370, and other additives are no better than the Series 1 oils as regards formation of scale and varnish on the piston group and the amounts of ash deposits in the combustion chamber (exhaust valves, piston heads). The smallest amounts of deposits were observed for

Table 2. Fouling of Parts after Long-Term Tests

a Условное обозначение масла	b Длительность испытаний, ч	c Нагарообразование на поршне, баллы: d сумма	e в том числе: f на канавке	g на юбке	h на дренажных отверстиях и в прорезях маслосъемных колец	i Количество нагара на поршне и кольцах, г	j Отложения в РМЦ за период испытаний, г
k 6% ВНИИ НП-360	800	59	31.5	6.6	11.2	17.8	1000
8% ВНИИ НП-360	800	57	28	5.7	13.5	21.7	990
5% ВНИИ НП-370	800	24	15	5.6	0.1	6.8	370
5% ВНИИ НП-370	1200	33	21	4.7	0	9.17	410
5% ВНИИ НП-370	1000	35.0	24.5	4.8	1.0	11.6	470
5% ВНИИ НП-370	800*	39	23	5.1	2.5	12.34	1150
l ЦИАТИМ-339 + ПМС'Я	800	25.5	16.1	4.8	0	7.9	3.0

*Oil-change interval 240 hours, elsewhere 120 hours.
KEY: (a) type designation of oil; (b) test time, hours; (c) piston scaling, points; (d) total; (e) including: (f) on groove; (g) on skirt; (h) on drainage holes and in slots of oil-control rings; (i) amount of scale on piston and rings, g; (j) deposits in RMTs during test period, g; (k) 6% VNII NP-360; (l) TsIATIM-339 + PMS'Ya.

operation on low-ash series 2 oils with ASK and MASK additives and with the imported Rimula oil, and the piston-group components were cleaner by factors of 1.5-2 than after running on Series 1 oils. Ring wear was slight during the test period and practically the same for the various samples, except for the oils with ASK and MASK additives, which permitted increased wear of the first compression ring.

Oils that had produced encouraging results in the short-term tests were given long-term tests, along with oils containing 6 and 8% of the VNII NP-360 additive, which are currently recommended for K-700 tractors.

Table 2 presents piston-group fouling ratings from the 800-hour tests; they confirmed the data of the short tests in indicating unsatisfactory detergent properties for oils with 6 and 8% of VNII NP-360 additive.

As we see from Table 2, increasing the additive concentration from 6 to 8% does not reduce the amount of scale formed, as indicated by the approximately identical over-all scaling ratings — 59 and 57 points, respectively, in the long-term tests and 39 and 37.5 points for the short tests. It was also noted that the top oil-control rings were less mobile and that the amount of deposits in the ring grooves and on the piston skirts was larger.

It was established in 800-hour tests on oils with VNII NP-360 additive that the drainage holes in the pistons and the

slots of the oil-control rings were 60-70% filled with carbon deposits, which might interfere with normal operation of the piston group if the engines were run any further. Also noted in operation on these oils was considerable fouling of the engine crankcase, clogging of the centrifuge rotor and the sections of the coarse filter. Table 3 gives the results of the long-term tests.

Table 3. Wear of Parts After Long-Term Tests

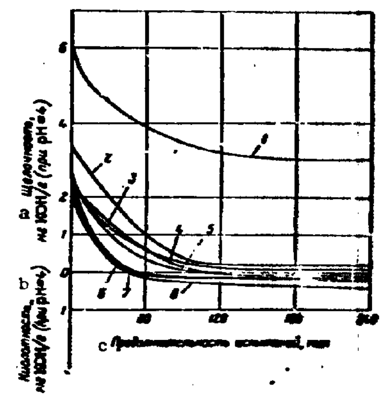
a Условное обозначение масла	b Длительность испытаний, ч	c Потери в весе, г		f Износ, мк		
		d первого кольца	e комплекта колец	g первого кольца по высоте	h первой канавки поршня	i гильзы
j 6% ВНИИ НП-360	800	0.205	0.31	11	34	12
8% ВНИИ НП-360	800	0.172	0.29	14	43	10
5% ВНИИ НП-370	800	0.46	0.73	33	25	11
5% ВНИИ НП-370	1200	0.68	1.1	56	36	5
5% ВНИИ НП-370	1000	0.57	0.705	49	39	8
5% ВНИИ НП-370	800*	0.42	0.64	39	38	11
k ЦИАТИМ-339 + ПМС'Я	800	0.72	1.02	60	46	11

*Oil change interval 240 hours.
KEY: (a) type designation of oil; (b) test time, hours; (c) weight loss, g; (d) first ring; (e) set of rings; (f) wear, μ; (g) first ring, height dimensions; (h) first piston groove; (i) sleeve; (j) 6% VNII NP-360; (k) TsIATIM-339 + PMS'Ya.

Satisfactory results were obtained from tests of Series 1 oils with 5% of VNII NP-370 and with the TsIATIM-339 and PMS'Ya additives.

In 800-hour tests, oils with 5% VNII NP-370 preserved full piston-ring mobility and moderate piston-group point ratings; the drainage holes were practically clean and there were only small deposits in the centrifuge. The test time for this oil was increased to 2000 and then to 3000 h for the same engine, with the parts checked for cleanliness and then cleaned after each test stage. With increasing engine running time, we note some increase in the fouling of parts as the piston group wears. Then 800-hour tests were conducted with a 240-h oil-change interval, with the result that scaling on the piston group increased to 39 points, while the amount of sludge increased from 8.6 to 12.9 g. Even in this case, however, the parts were cleaner than after operation on oil with VNII NP-360 additive.

Oil with 6 and 8% of the VNII NP-360 additive indicated superior antiwear properties in the long-term tests. Some increase in the wear figures was noted after operation on oil with the additive TsIATIM-339 + PMS'Ya (see Table 3).



Change in alkalinity of oil:
1) ASK + MASK; 2) 5% VNII NP-370;
3) Series 1; 4) TsIATIM-339 + PMS'Ya;
5) BashNII-2; 6) BPK + SB-3; 7)
8% VNII NP-360; 8) 6% VNII NP-360.
KEY: (a) alkalinity, mg of KOH/g (at pH = 4); (b) acidity, mg of KOH/g (at pH = 4).

Oil quality (apart from detergent and antiwear properties) was also evaluated from the chamfer-surface condition of the exhaust valves, which were made from EI-69 steel (both without facing of the chamfer and with a VZK-alloy facing). It was found after the tests that the built-up valve chamfers were in better condition than the unfaced chamfers for all of the oils.

It should be noted that formation of a glasslike film on the valves (both faced and unfaced types) had been noted previously in a number of cases. The gases are usually pulled into cracks and pits in this film, occasionally burning valves.

This glasslike film on the valves was not observed in our tests of oil with VNII NP-360 additive.

The problem of glass-film formation on the exhaust-valve chamfers in operation on oils with certain additives requires special study.

Particular attention was devoted to the change in the oil's neutralizing properties in analyzing the oils during these tests.

For this purpose, the alkalinity of the crankcase oil was determined during the testing process. The figure shows the analytical results. Alkalinity drops off most sharply in the oil with 6% of VNII NP-360. With this specimen, strong acids were detected even after 60 hours of operation, and their content subsequently increased. Increasing the additive concentration to 8% had little influence on the neutralizing-property change.

Oil with 5% of the additive VNII NP-370 has the largest alkalinity reserve. Oil with the combined additives TsIATIM-339 + PMS'Ya has almost the same alkalinity. The alkaline properties are retained in these oils undil they are drained; in other oils of Series 1, high acidity is found after as little as 120 hours of operation. Series 2 oils retained their alkaline properties to the end of the test.

The figure shows that the alkalinity of the oil drops most rapidly during the first few hours of operation, and that this drop is more abrupt in the oils with the VNII NP-360 and BFK + + SB-3 additives. Oil alkalinity then stabilizes as a result of addition of fresh oil and filtering out of the oxidation products. The data plotted in the figure are in good agreement with the results of engine-parts inspection after the tests.

Conclusions

1. It was established by the tests that the best oil for the YaMZ-238NB engine is the Series I oil with 5% VNII NP-370, 2% PMS'Ya, 0.5% LZ-23k and 0.005% PMS-200A. This oil was recommended for field testing.

2. Oil with the TsIATIM-339 + PMS'Ya additive, whose properties resemble those of the Series 1 oils, is also recommended for use testing.

3. Rather heavy deposits are formed on the piston group, in the centrifuge rotor, and in the engine crankcase when the engine is run on oil with the VNII NP-360 additive; this additive does not meet the requirements for dependable operat[illegible] of the engine on sulfur-containing fuels.

4. Operating experience and the [illegible] that different batches of oil with the VNII NP-[illegible] differ in quality. The physicochemical indices stated [illegible] do not give a complete picture of the motor prop[illegible] oil. It is therefore necessary to formulate and intr[illegible] into the GOST quick oil-property motor-rating methods, so that the refineries will be able to indicate their results on the tags accompanying the oil.

EFFECTIVENESS OF USING ADDITIVES IN HYDRAULIC-COUPLING OILS FOR PASSENGER AUTOMOBILES

O.S. Obleukhova and N.N. Kryucheshnikova

The operating conditions of the oil used in motor-vehicle hydraulic transmissions – automatic transmissions and torque converters, power-steering gear, etc. – are characterized by: a broad temperature range (from -60°C for vehicles used in the northern regions to +130°C); high specific pressures; small clearances (especially in automatic transmission controls); by the presence of parts containing substantial amounts of copper (up to 60% in sintered brakebands); by contact with rubber gaskets and hoses.

None of the mineral oils can guarantee dependable long-term service from these units, since these oils cause increased wear and formation of deposits that interfere with operation of the automatic controls and other assemblies.

VNII NP-1 oil, which is made by using polyisobutylene to thicken a light deep-refined and deparaffinated oil with DF-1, *phenyl-α-naphthylamine, and VNII-SK* additives, is produced at the present time for passenger-car automatic transmissions. These additives are used to improve the viscosity, antiwear, anticorrosion, antifoaming and antioxidant properties. The quality indicators of this oil are given in Table 1.

User experience with VNII NP-1 oil has indicated that its quality must be improved, since the test consignments of the oil had a pour point of minus 44°C, while the standard specifies minus 35°C and commercial consignments pour at minus 32°C. Use

Table 1. Oil Properties

a Показатели	b ВНИИ НП-1 ГОСТ 10660—63	c Загущенная основа масла ВНИИ НП-1 + МАСК + + ДФ-11	d Веретенное АУ + МАСК + + ДФ-11
e Вязкость, сст			
f при 100 °С	7.61	7.36	3.53
» 50 °С	26.32	25.11	12.28
» −20 °С	1902	2094	1162
» −30 °С	—	—	4180
» −40 °С	—	—	~14 000
g Температура застывания, °С	−35	−50	−46
h Коррозия медной пластинки при 100 °С в течение 3 ч	i Цвета побежалости	j Отсутствует	
k Термоокислительная стабильность на приборе ДК-2			
l осадок, %	1.15	•	•
m кислотное число, мг КОН/г масла	0.03	1.50	1.25
n реакция	o Слабощелочная	p Нейтральная	
q Испытания на ЧШМ-3			
r нагрузка заедания, кГ	71	78	78
s нагрузка сваривания, кГ	224	224	178
t ОПИ	34	36	36
u Набухание резины марки 78 в течение 72 ч при 130 °С, %	±2.0	+0.5	−1.9

KEY: (a) indicator; (b) VNII NP-1 GOST 10660-63; (c) thickened base of oil VNII NP-1 + MASK + DF-11; (d) AU spindle oil + MASK + DF-11; (e) viscosity, cst; (f) at; (g) pour point, °C; (h) copper-plate corrosion in 3 hours at 100°C; (i) temper color; (j) none; (k) thermal oxidation stability in DK-2 machine; (l) sediment, %; (m) acid number, mg of KOH/g of oil; (n) reaction; (o) weakly alkaline; (p) neutral; (q) tests on ChShM-3; (r) seizing load, kg; (s) welding load, kg; (t) OPI [generalized wear index]; (u) swelling of type 78 rubber in 72 hours at 130°C, %.

of the oil is limited by its high viscosity at low temperatures.

The oil has excessive corrosive aggressiveness toward copper. Copper-plate tests at the operating temperatures of the oil (110-130°C) indicate the formation of a black, loosely attached film that accelerates part wear. The oil has inadequate antioxidation stability, and this makes it necessary to change it at least every 26 thousand kilometers.

The methods provided by GOST 10660-63 for rating the stability of oil in the VTI [All-Union Heat Institute] machine do not characterize the behavior of the oil in use; neither does holding the oil at 140°C for 24 hours, in both cases because of the mild oxidation conditions.

The NAMI [Central Automobile and Automotive-Engine Scientific Research Institute] DK-2 machine was used for stability evaluation of the oils; VNII NP-1 and several Type A (General

Motors) oils developed abroad for the same application were tested in it at various temperatures.

It was established that sediment forms after 21 hours of 160°C oxidation of VNII NP-1 oil, and that it amounts to 1.06% after 50 hours, while sediment forms in the imported oils only after 177-182 hours.

A copper plate with the same dimensions as the lead plate used in determining the corrosive aggressiveness of oils in the NAMI DK-2 machine was used as a catalyst. This made it possible to shorten the testing time significantly (by 30-40%) and to test the influence of the oil on the copper plate. The following method of evaluating the stability of oils used in hydraulic systems was selected on the basis of a series of tests: after oxidation in the NAMI DK-2 device for 60 hours at 160°C in the presence of the copper plate, the oil may not form sediment even on subsequent solution in ten times the amount of isooctane (or petroleum ether) and storage of the solution for 24 hours. Formation of a black film that cannot be rubbed off the copper plate is acceptable.

Additives that confer improved stability on VNII NP-1 oil were selected by the method indicated.

The best results were obtained with VNII NP-1 oil to which the following additives were introduced: MASK (4-4.5% with a calcium content of 0.15-0.18%), DF-11 (2-2.2% at a zinc content of 0.1%) and PMS-200A (0.005%) as an antifoaming additive.

The laboratory tests showed that the experimental oil has high antioxidation stability and good antiwear and anticorrosion properties (see Table 1). It was also established that MASK additive made from a heavy raw material acts as a depressor and lowers the pour point of VNII NP-1 oil to minus 49°C. When MASK additive made from light raw materials is used, the pour point of the oil can be lowered by adding 0.3-0.5% of polymethacrylate D.

VNII NP-1 oil with the new additive combination was tested in the fluid transmissions of ZIL-111 passenger cars. The transmission parts were measured with the micrometer at the beginning of the tests and after 50 thousand kilometers. Oil samples were taken for control purposes at 25-thousand-km intervals. The oil was not changed until the vehicles had accumulated 55 and 100 thousand km. The test results were compared with data obtained with VNII NP-1 oil and imported Shell Donax T-6, which were changed every 25 thousand km.

The results of use tests with the experimental oil were evaluated on the basis of deposits formed on transmission parts and in the transmission sump, transmission trouble, the wear of its parts, the behavior of the rubber packing components, and the change in oil quality during operation.

Use of the test oil without changes for 55 and 100 thousand km kept the transmissions running normally. When the units were disassembled, no oil-oxidation products could be detected in the form of gummy deposits, varnishes, etc., either in the automatic-control unit (control panel, reduction-valve panel, housing of centrifugal spool) or on other hydraulic-transmission or torque-converter parts. There was 5-6 g of sludge in the bottom of the case after 50 thousand km, and it consisted basically of inorganic impurities.

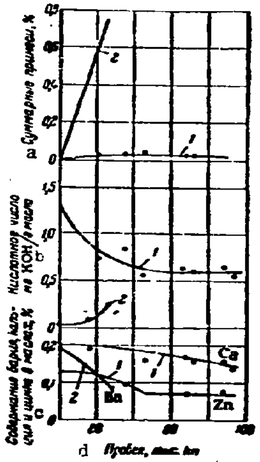


Fig. 1. Changes in additive-component contents, acid number and total impurities in oil as a function of engine mileage. 1) test oil; 2) VNII NP-1 oil.
KEY: (a) total impurities, %; (b) acid number, mg of KOH/g of oil; (c) barium, calcium and zinc contents in oils, %; (d) mileage, thousands of km.

When the transmissions were run with VNII NP-1 oil, there were ~20 g of sump deposits at 25 thousand km. Sludging was also observed in the passages of the panel case and in the reduction valves, in some cases causing them to stick.

No parts of the hydraulic transmissions run on the test oil showed deep scoring or temper colors. For the most part, the parts had worn by 0.01-0.015 mm after 93 thousand km; only on one part did the wear amount to 0.08 mm (as against a maximum acceptable wear of 0.2-0.3 mm).

The clutch is the basic element in determining the dependability and service life of a hydraulic transmission. In operation on the test oil, the wear of the sintered-metal clutch disks was practically nil, and no dark films formed on their surfaces. The test results indicated that the test oil is on a par as regards antiwear properties with the imported Shell Donax T-6. When VNII NP-1 oil was used, the sintered parts showed more rapid wear. Analysis of oil samples taken during the tests showed that the viscosity level dropped somewhat in both the commercial VNII NP-1 oil and in the test oil (by 3-4 cst at 50°C) as a result of destruction of the viscosity additive.

The oxidation-product content of the test oil (the organic part of the total impurities) was insignificant, and did not exceed 0.02-0.03% over the entire useful life of the oil (93 thousand km), while it was 0.54%, including 0.32% of asphaltenes in the VNII NP-1 oil and the

inorganic part of the impurities (0.21%) contains a considerable amount of spent DF-1 additive. For this reason, the acid number of the oil decreased considerably (Fig. 1).

The concentration change of the MASK and DF-11 additives in the test oil during operation was insignificant (see Fig. 1).

The following conclusions may be drawn from the test results.

Introduction of the MASK, DF-11 and PMS-200A additives into the thickened VNII NP-1 oil base produces passenger-car automatic-transmission oils with good antiwear, anticorrosion, and antioxidant properties. The depressor properties of the oil can be improved by introducing 0.3-0.5% of polymethacrylate D.

The high stability of this oil makes it possible to increase the change interval substantially and reduce operating consumption. Even with changes at 50 thousand km, oil consumption is reduced by 40-45% by comparison with the commercial VNII NP-1 oil.

Power-steering oil. The oil used in automatic transmissions and torque converters is usually also used in power-steering systems. Good viscosity-temperature properties in this oil are especially important during starting of the engine and steering-booster pump. VNII NP-1 oil is fully adequate for passenger automobiles, but its viscosity-temperature properties have been found unsatisfactory for trucks and buses, which are generally parked outdoors.

It was established by special tests run on ZIL-130 vehicles that at air and pump-oil temperatures of minus 50°C, the oil temperature is raised to minus 40°C during the prestart warmup of the engine, and then reaches 0°C within 1-2 min after the pump has started. Under these conditions, normal operation of the pump can be ensured by use of an oil with a minus 40°C viscosity not above 15-18 thousand cst and a pour point below minus 45°C.

It should be noted that use of AGM and AMG-40 light commercial oils, which have good viscosity-temperature properties, results in increased wear of parts.

The viscosity of the oil is lowered when VNII NP-1 oil is used in the steering hydraulic booster; after 4 thousand km, the 50°C viscosity has fallen from 26 to 16-18 cst. This substantial viscosity drop is explained by destruction of the viscosity additive, which results both from the high running temperature of the oil (up to 130°C) and the incessant throttling (since the pump delivers 10 liters/min at 600 rev/min and the excess of oil is directed through the transfer valve when crankshaft speed changes).

Thus, acquisition of an oil with good operational properties requires: a base with good viscosity-temperature properties; a viscosity additive with high thermal and mechanical stability; an antiwear additive that ensures long service life and dependable operation of the power-steering gear in all of the country's climate zones; an antioxidant to provide a long oil-service life, and an antifoaming additive.

It is also necessary to consider the effect of the oil on rubber gaskets.

In developing the oil, we took as the base AMG-10 oil with various viscosity additives (Vinipol, polyisobutylene, polymethacrylate) and type AU spindle oil from Zhirnovsk petroleum.

The antiwear and antioxidant additives for these oils were first tested in various combinations on a friction machine and then checked on the DK-2 machine in order to obtain test specimens whose antiwear properties and stability would meet the specifications for automatic-transmission oils.

The following additive combinations were chosen: MASK (4%) and DF-11 (2.3%); chlorinated paraffin (5%) and MB-1[1] (1%).

Experimental specimens of the oils were given bench tests in steering-gear hydraulic booster pumps under the following forced conditions.

Running in: pump load 125 cycles in 1 min; oil pressure drop across system under various loads: P_1 = 10-20 kg/cm² for 10 hours, oil temperature 115-125°C; P_2 = 10-45 kg/cm² for 10 hours, oil temperature 115-135°C. Pump shaft speed 3000 rev/min.

The normal operating regime of the pump differs only in having a higher pressure (10-55 kg/cm²).

The tests lasted 150-200 hours. Each oil specimen was tested in four or five pumps.

The quality of the oils was evaluated from the change in their physicochemical constants and from the wear of the pump stator, characterized by the increase in its smallest diameter and its loss of weight (readings taken every 50 hours).

The oils were comparison-tested with commercial oils — spindle AU, AMG-10, VNII NP-1, and the imported Shell Donax T-6 oil.

TEST RESULTS

Antiwear Properties

The results of the pump stator wear readings are plotted in Figs. 2 and 3, from which we see that:

[1]See page 39 for footnote.

stator wear reaches its limit (1.25 mm) after [illegible] hours of running on AMG-10 commercial oil;

on introduction of the chlorinated-paraffin and MB-1 additives into the thickened AMG-10 and spindle AU oil bases, no substantial decrease in stator wear is observed;

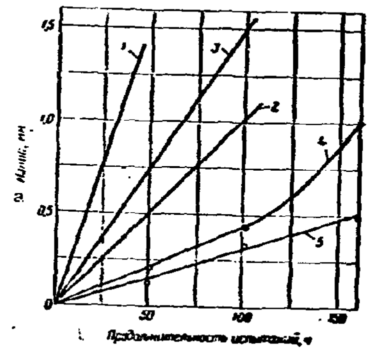


Fig. 2. Pump stator wear on various oils. 1) commercial AMG-10; 2) AMG-10 with polymethacrylate, chlorinated paraffin, and MB-1; 3) AMG-10 with polyisobutylene, chlorinated paraffin and MB-1; 4) AU spindle oil; 5) AU spindle oil with chlorinated paraffin and MB-1.
KEY: (a) wear, mm; (b) test time, hours.

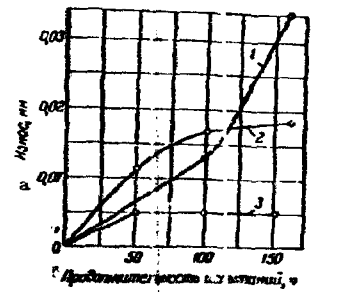


Fig. 3. Pump stator wear on various oils. 1) AMG-10 with polyisobutylene, MASK and DF-11; 2) VNII NP-1; 3) AU spindle oil with MASK and DF-11.
KEY: (a) wear, mm; (b) test time, hours.

on introduction of the MASK and DF-11 additives into these oils, wear is reduced substantially, especially in the case of spindle AU, where the wear ranges from 0.001 to 0.005 mm after 170 hours of testing;

after 160 hours, the wear of a stator run on VNII NP-1 commercial oil is 0.005-0.025 mm, while the same oil with the MASK and DF-11 additives gives 0-0.005 mm after 200 hours.

There is practically no stator wear when the imported Shell Donax T-6 oil is used. The best results as regards antiwear properties were obtained with the domestic MASK and DF-11 additives.

Viscosity Properties

The bench tests showed that the viscosity additives undergo considerable destruction. Figure 4 shows the changes in oil

viscosity during the tests.

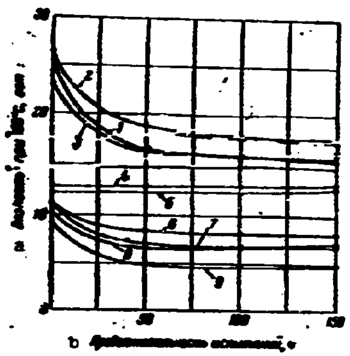


Fig. 4. Change of oil viscosity as a function of test time. 1) commercial VNII NP-1; 2) VNII NP-1 with polyisobutylene, MASK and DF-11; 3) import type A; 4) spindle AU; 5) spindle AU with MASK and DF-11; 6) AMG-10 with Vinipol, chlorinated paraffin and MB-1; 7) AMG-10 with polyisobutylene, chlorinated paraffin and MB-1; 8) AMG-10 with polyisobutylene, MASK and DF-11; 9) AMG-10 with polymethacrylate, chlorinated paraffin and MB-1.
KEY: (a) 50°C viscosity, cst; (b) test time, hours.

The greatest viscosity loss is observed when polymethacrylate (51.6%) and polyisobutylene (32-40%) are used; the viscosity decrease is smaller with Vinipol (19.4%). The viscosity level of the imported oil also falls by 30%.

Characteristically, the viscosity drops during the first few hours of operation, with some stabilization observed after 50 hours.

The viscosity of AU spindle oil rises slightly (by 0.39 cst at 50°C) as a result of formation of asphalt tars. The stability of the oil is raised by introduction of additives, so that its viscosity remains practically constant (0.09-0.2 cst at 50°C after 150 hours of testing).

These tests showed that commercial viscosity additives with molecular weights not below 10,000 should not be used in power-steering oils. Distillate oils such as spindle AU, which have lower viscosity levels at the working temperatures, lubricate the rubbing surfaces satisfactorily in the presence of antiwear additives.

The antioxidation stabilities of the oils cannot be determined conclusively from the results of bench tests because of their short duration (150-200 hours). The total-impurity content is insignificant in all oils, ranging from 0.01 to 0.02%, with asphaltenes completely absent from the filtered oil. The acid number of AU spindle oil rises from 0.04 to 0.15 mg of KOH/g, but in oils containing the MASK and DF-11 additives, it declines as the additives are depleted, from 1.26 to 1.11 mg of KOH/g. However, the color of the test oil did not change during the tests, indicating that it has good stability to oxidation.

The bench tests made it possible to recommend spindle oil AU with the MASK, DF-11, and PMS-200A additives for road testing in the country's various climate zones.

Conclusions

1. Introduction of the MASK (~4%), DF-11 (~2.2%) and PMS-200A (0.005%) additives into oil improves their antiwear, antioxidant, anticorrosion, and antifoaming properties considerably, with the result that the dependability and service lives of automotive automatic transmissions and power-steering pumps are substantially improved.

2. The high antioxidation stability of oil with these additives makes it possible to use it 2-3 times longer and reduces operational oil consumption.

Footnote

Manuscript page	
35	[1]MP-1 additive (4,4-methylene-bis-2,6-tert-isobutylphenol).

COMBINATION OF ASH-FORMING AND POLYMERIC ASH-FREE ADDITIVES IN MOTOR OILS AS A WAY TO FURTHER QUALITY IMPROVEMENT

Ye.G. Semenido, I.A. Traktovenko, N.V. Shchegolev, M.A. Senichkin, A.S. Lozar' and V.I. Sharapov

As we know, only metal-containing organic compounds (ashing additives), and especially calcium and barium alkylphenolates and their sulfur- and phosphorus-containing derivatives, are used as detergent, dispersing, anticorrosion and antioxidation additives to motor oils produced by the domestic petroleum industry. Sulfonates of alkaline-earth metals and zinc dialkyldithiophosphates are also used.

Depending on application, motor oils may contain 6-10% and more of these ashing additives. However, when engines are run on oils containing large amounts of ashing additives, their rubbing parts, and especially their cylinder-piston groups, wear rapidly. This wear is a consequence of carbonization of the oils in hot areas of the engines, with formation of the oxides of the metals.

The "hotter" and more powerful the engine, the more rapid is the depletion of the ashing additives in its motor oil. To compensate for depletion, larger amounts of the additives are introduced into the oils. Depletion of the ashing additives is also influenced by cold engine operation under city traffic conditions, when the hydrophilic properties of the ashing additives (salts of alkaline-earth metals) are manifested most strongly, i.e., formation of low-temperature deposits is intensified.

Thus, together with their good detergent and dispersing properties, asning additives have important disadgantages that make it necessary to reduce the content of these additives in engine oils.

The necessary detergent, dispersing, and antiwear properties can be obtained in motor oils with minimum contents of ashing additives if nitrogen-containing polymer (nonashing) additives are introduced into the oils.

The nonashing additives belong to the class of polar polymers and are copolymers of methacrylic acid alkyl esters with certain nitrogen-containing monomers, such as methylvinylpyridine, diethylaminoethylmethacrylate, etc.

In the research whose results are reported below, we used VNM nonashing additives prepared by V.G. Telegin and Ye.V. Lazareva [1].

To determine the effectiveness of the nonashing additives in combination with ashing types, a motor oil containing these additives was tested on a YaMZ-236 diesel engine. The test results were compared with the results of tests made with the same engine under similar conditions using motor oils with only the ashing additives. Each sample was tested for 150 hours.

The detergent, dispersing and antiwear properties of the additives are evaluated on the basis of:

the quantity and type of deposits on the engine parts and oil filters;

piston-ring freedom;

the wear of engine parts and their condition;

the change in the physicochemical properties of the drained oil.

It has been established by previous studies and tests [2] that 5% of ashing additives (3% SB-3 2% DF-11) can be used in motor oils for type YaMZ-236 diesels and type ZIL-130 V-type carburetor engines. In motor oils made from eastern petroleums and used in diesels, this additive content gives only satisfactory results.

To ascertain the possibility of obtaining a sharp increase in the quality of oil containing the acceptable amount of ashing additive by adding the VNM nonashing additive to it, we tested oil A, which was type ASZp-10 containing 3% SB-3, 2% DF-11 and 5% VN-18 (Table 1).

The results were compared with the results of tests made with oils having high ashing-additive contents: oil B, which was

Table 1. Results of Analysis for Physicochemical Properties

a	b	c	d	e	f	g: h	g: i
A	9.66	3.60	0.330	0.41	0.654	[illegible]	−40
j Б	10.58	4.23	0.590	0.98	1.290	[illegible]	−35
k В	10.30	5.95	0.505	1.63	0.132	[illegible]	[illegible]
l Э	10.71	5.77	0.636	1.04	0.021	[illegible]	−40

KEY: (a) oil; (b) viscosity at 100°C, cst; (c) ratio; (d) ash content, %; (e) coking capacity, %; (f) acid number, mg of KOH/g; (g) temperatures, °C; (h) flash point; (i) pour point; (j) B; (k) V; (l) E.

Table 2. Deposits on Engine Parts

a	b			f		
	c	d	e	g	h	i
A	10–15	50–70	1.0–1.5	25.3	190	[illegible]
j Б	35–45	90–95	2.5–3.0	29.8	580	45
k В	60	80–90	3.0–3.5	27.2	820	[illegible]
l Э	30–35	80–90	2.0–2.5	24.1	385	[illegible]

KEY: (a) oil; (b) condition of pistons; (c) % of piston-shirt area coated by varnish; (d) % of piston head area covered by scale; (e) PZV result, points; (f) deposits on parts, g; (g) total amount of scale; (h) deposits in centrifugal filter; (i) deposits in coarse filter; (j) P; (k) V; (l) E.

type ASZp-10 with 9% of ash-forming additives (7% SK-11 and 2% DF-11), and oil V, which was type DSp-11 with 6% of VNII NP-360, as well as a standard (E) oil of type DSp-11 with 4% Monto 613 and 0.25% Santolube 493, the latter corresponding to Series 1.

It is known that the serviceability of an engine is largely determined by the deposits on its parts. They are responsible for most cases of engine trouble. Table 2 presents data on the deposit-forming properties of the oils.

Piston-ring freedom is judged from the number of rings that can be shifted with little effort (there were no stuck rings in any of the tests); there were two such rings in the tests of oil A and three each in the tests of oils B, V and E.

Table 3. Test Results

a	b									
	c			g					m	
	d	e	f	h	i	j	k	l	n	o
A	8.0	7.0	7.5	0.10	0.05	0.03	0.01	0.01	0.05	0.03
p Б	8.0	7.5	8.0	0.13	0.06	0.04	0.02	0.01	0.06	0.05
q B	8.0	8.5	8.5	0.11	0.04	0.03	0.01	0.01	0.03	0.02
r Э	7.0	6.5	7.0	0.13	0.06	0.04	0.03	0.02	0.07	0.05

KEY: (a) oil; (b) engine-part wear; (c) cylinder liners, μ; (d) in plane perpendicular to crankshaft axis; (e) in plane parallel to crankshaft axis; (f) average; (g) piston rings, g; (h) first compression ring; (i) second compression ring; (j) third compression ring; (k) first oil-control ring; (l) second oil-control ring; (m) connecting-rod inserts, g; (n) top; (o) bottom; (p) B; (q) V; (r) E.

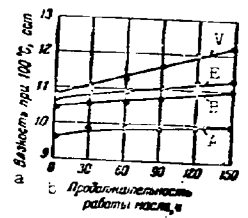


Fig. 1. Change in viscosities of oils during running in YaMZ-236 engine.
KEY: (a) 100°C viscosity, cst; (b) oil service time, hours.

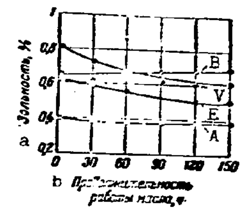


Fig. 2. Change in ash content of oil during running in YaMZ-236 engine.
KEY: (a) ash, %; (b) oil service time, hours.

The wear and condition of the engine parts were approximately the same after tests with each of the above oils. There were minor differences in piston-ring and connecting-rod-insert wear (Table 3). The surface of the oil pan was clean after the tests of oils A and E, but it was covered with gummy deposits in the other cases.

Changes in the physicochemical properties of the used oils indicate high stability for oils A (with the nonashing additive)

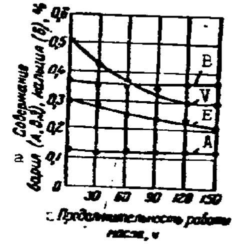


Fig. 3. Change in metal content of ash additives in oils during running in YaMZ-236 engine.
KEY: (a) contents of barium (A, V, E) and calcium (B), %; (b) oil service time, hours.

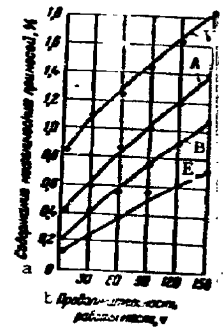


Fig. 4. Change in mechanical-impurity content in oils during running in YaMZ-236 engine.
KEY: (a) mechanical-impurity content, %; (b) oil service time, hours.

and E (the reference oil) by comparison with oils V, which contained 6% of VNII NP-360 (Figs. 1-3). But even at increased concentration (6%) in ordinary oil, VNII NP-360 additive does not fully guarantee Series 1 quality.

Table 4. Results of Tests on GAZ-51 Engine

a	b	c		f		i		
		d	e	g	h	j	k	l
A	0.9	0.064	0.012	0.018	0.017	8	4	10
m B*	3.6	0.093	0.063	0.023	0.014	115/70**	29/57**	144/122**
n Э	1.6	0.065	0.011	0.014	0.007			

*Oil specimen with 3.5% VNII NP-360 additive tested.
**The denominator gives the result for oil with 6% VNII NP-360.
KEY: (a) oil; (b) average diametral cylinder wear, μ; (c) average piston-ring wear, g; (d) compression rings; (e) oil-control rings; (f) average insert wear, g; (g) top; (h) bottom; (i) amount of deposits, g; (j) in crankcase; (k) in valve cover; (l) total; (m) V*; (n) E.

The detergent and especially the dispersing properties of this additive are clearly inadequate to ensure normal diesel performance. Thus, Fig. 4 and Table 2 indicate that oil V with the VNII NP-360 additive contained 1.8% of mechanical impurities by the end of the tests, there were 820 g of sludge in the centrifugal filter, while the corresponding figures for oil E (Series 1) were 0.7% and 365 g, for oil A (with the nonashing additive) 1.4% and 190 g, and for oil B 1.1% and 510 g.

The piston-wear rating after the tests was 3-3.5 points for oil V and 2-2.5 and 1-1.5 points, respectively, for oils E and A.

A consequence of the inadequate dispersing properties of VNII NP-360 additive is a relatively sharp increase in oil viscosity during work (see Fig. 1). The fast depletion of this additive (see Figs. 2 and 3) is also partly responsible for its decreased effectiveness.

Comparative 28-hour cold tests run on the GAZ-51 engine with oils having ashing additives and a mixture of ashing and nonashing types indicated superiority of oils with the additive mixture (Table 4). Running on these oils, the engine forms smaller amounts of low-temperature deposits. Also less conspicuous is the influence of acid products in the oil, high contents of which are characteristic for cold engine operation, on the wear of rubbing parts.

Inspecting the above data, we may conclude that combining ashing and nonashing additives in a motor oil endows it with high operational properties, while the ashing additives taken alone improve one indicator at the expense of others.

A nonashing additive in the combination of additives introduced into a motor oil improves its viscosity-temperature properties (VI, viscosity at 0°C, etc.).

The quality margin of oil A indicates the possibility of reducing the proportion of ashing additives in the oil when they are used in combination with the nonashing additive. This is also confirmed by the good results of the 100-hour test run in the YaMZ-236 engine on a thickened oil containing the type VN nonashing additive, 2.5% of SB-3, and 1% of LANI-317.

In the production of ordinary motor oils containing ashing and ash-free additives (in various combinations), it is necessary, in view of the thickening tendency of the latter, to take initial distillate or residual oils with somewhat lower viscosity levels than when the ashing additives are used alone.

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2. Semenido, Ye.G., Milyutikov, Yu.D. Shchegolev, N.V., Runenkov, A.V., Sherement, M.I., and Sazontov, Yu.P., Avtomobil'nyy transport, No. 4, 19-22 (1965).

SELECTION OF OPTIMUM ADDITIVE COMBINATIONS FOR MOTOR OILS ON A BENCH WITH A SINGLE-CYLINDER AIR-COOLED ENGINE

[illegible] Filippov and [illegible]

Soviet and certain foreign methods for the spot-testing of oils and additives with single-cylinder engines do not consider the effect of blow-by into the crankcase, oil consumption during engine operation, and other variables that exert substantial influence on the test results. Moreover, domestic oil and additive tests are carried out for the most part on benches and engines designed for other purposes, which require comparatively large amounts of the sample to be tested.

In view of this, work has been done toward the creation of a special apparatus for testing oils and additives for use in carburetor engines and development of a motor rating method for their operational properties at high temperatures.

The equipment was designed with consideration of the following basic requirements.

1. It is necessary that the bench engine be sensitive to oil quality, have a degree of thermal stressing and other indices that aid in simulating various modern engines, perform normally and without breakdown on a broad quality range of oils, and permit differential evaluation of these oils.

2. The design of the engine should permit regulation of the [illegible] oil and fuel consumptions, the applicated-air temperature, blow-by of gases into the crankcase, exhaust-gas pressure, and other indices and holding them at the desired levels.

3. It must be possible to vary the crankcase oil temperature over a broad range with the aid of a heat carrier that prevents carbonization of the oil in the crankcase and on the electric-heater walls.

4. The crankcase design must make it possible to run tests with minimal quantities of the oil without failing to lubricate the rubbing parts normally, as well as draining the oil [illegible] and as thoroughly as possible after testing and [illegible] deposits from the crankcase walls.

5. It is necessary that the [illegible] engine perform normally on oils with a broad viscosity range [illegible] oils to the MS-20 and MK-22 aviation [illegible], so that quality ratings can be obtained for [illegible] oils under these conditions.

The requirements listed above are [illegible] fully satisfied [illegible] model [illegible]-1 single-cylinder [illegible] all-[illegible] "[illegible]" engine, whose design (Fig. 1) was modified as follows:

1. The cooling-control mechanism was modified by installing the additional venetian-blind-type shutter 27 to provide uniform distribution of the cooling-air flow; this made it possible to raise cylinder temperature to [illegible] and the corresponding piston temperature to 270-[illegible].

[illegible]. The engine's oil sump [illegible] is spherical, with heat carrier [illegible] ethylene glycol mixed with water circulated between the crankcase wall and the sump to heat or cool the oil. The oil-heating system consists of condenser [illegible], which was taken from an IT[illegible] installation, the type MSh-[illegible] gear-type oil pump 28, the type [illegible] electric motor 2[illegible], and the electric heaters [illegible]3, also from the IT[illegible].

[illegible]. The rubbing pairs are lubricated by oil sprayed through holes 10. Pressurized oil passes through calibrated orifice [illegible] into oil pan 22, which is located under the crank. Drain hole 12 is provided to maintain a constant oil level in the pan. Slinger 11 is screwed into the connecting-rod bearing cap. The slinger is fixed in position with a lock nut. The connecting-rod bearing is oiled by splash from the slinger as the crankshaft turns. Oil consumption is regulated between [illegible] and [illegible] g/hour with ± 1 g/hour fluctuations.

4. The supply system of the bench engine is also equipped with a tube-type electric heater, which provides for a considerable range of variation of intake-air temperature (from 30 to [illegible]) and maintaining it constant in this range to within ±1°[illegible].

5. The [illegible] of the cylinder [illegible] replaced by special device to permit artificial deformation in order to regulate blow-by.

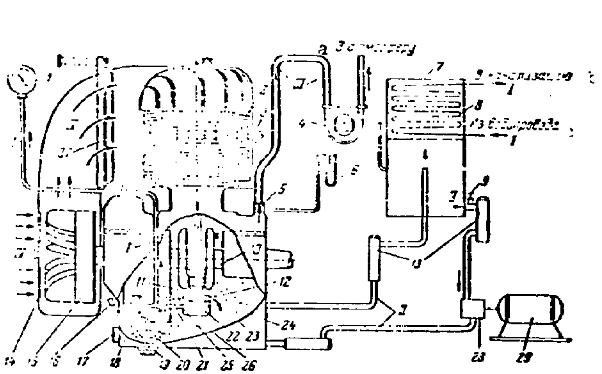

Fig. 1. Diagram of lubricating, cooling and ventilating system of crankcase in IKM-1 installation. 1) pressure gauge (0-1 kg/cm²); 2) device for regulating rate of blow-by into engine crankcase; 3, 9) chromel-alumel thermocouples; 4) type GK gas meter; 5) oil-filler pipe; 6) water manometer; 7) IT-9 condenser; 8) cooling coil; 10) holes for lubrication of connecting-rod bearing; 11) slinger; 12) drain hole; 13) ITP heaters (N = 1 kW; V = 127 V); 14) regulating baffles; 15) flywheel fan; 16) TK contact thermometer; 17) temperature controller; 18) oil pump; 19) drain plug; 20) oil pickup; 21) reducing valve; 22) oil pan; 23) crankcase oil sump; 24) glycerine (ethylene glycol); 25) calibrated orifice; 26) test oil; 27) supplementary louver-type baffles; 28) VSh-3A gear pump; 29) AOL 32-4 electric motor (N = 1 kW). Lines: I) motion of oil under pressure; II) circulation of ethylene glycol or glycerine; III) removal of gases blown into engine crankcase; IV) motion of cooling air. KEY: (a) to atmosphere; (b) to sewerage; (c) tap water.

The quantity of blown-by gases is measured with the type GK gas meter 4.

6. The temperature state of the engine is monitored by the use of thermocouples and a type EPP-09 recording electronic potentiometer.

An electric brake is provided by a type EL 1/4 induction motor (power 5.8 kW, n = 1450 rev/min).

The oil-testing unit thus devised with its single-cylinder carburetor engine was given the designation IKM-1.

The following test conditions were adopted as a result of preliminary results.

Test time, hours	10
Effective output, hp	[illegible].3±0.1
Crankshaft speed, rev/min	[illegible]00±25
Per-hour fuel consumption, kg/h	[illegible].67±0.01
Spark advance, degrees	[illegible]1±0.5
Temperatures, °C:	
cylinder	[illegible]0±2
oil in crankcase	[illegible]5±1
Per-hour oil consumption, g/h	10±1
Amount of oil tested, kg	0.5

To determine the depletion of the oils and additives, we conducted tests lasting up to 40 hours with evaluation of indicators after 10, 20, 30 and 40 hours without oil changing, but with 120 g added every 10 hours.

Oil quality was rated on the basis of the following indicators:

the motor index I_m in points, reproducibility ±10%;

the deposit index I_o in points, reproducibility ±10%;

piston-ring freedom, P_k, in points, reproducibility ±30%.

The scale against which ring mobility was evaluated is given in Table 1.

Table 1. Scale of Ring-Mobility Rating

a) Состояние колец	b) Оценка баллы	a) Состояние колец	b) Оценка баллы
c) Чистое перед испытанием	0	h) Закоксованное:	
d) Свободно падающее с металлическим звуком	1	i) слегка	5
e) Свободно падающее	2	j) частично	6
f) Свободно падающее с глухим звуком	3	k) полностью	7
g) Инертное	4	l) Пригоревшее на:	
		0—90°	8
		90—180°	9
		150—360°	10

KEY: (a) condition of rings; (b) rating, points; (c) clean, before testing; (d) drop freely with metallic sound; (e) drop freely; (f) drop freely with dull sound; (g) inert; (h) stuck; (i) slightly; (j) partially; (k) completely; (l) turned.

The arithmetic mean value was used in the calculation to determine the mobility rating for each ring.

The color of the deposits in the piston-ring zone (Ts_{zk}) and on the piston skirt (Ts_{yu}) was determined from the VNII NP (All-Union Scientific Research Institute of Oil and Gas Processing

and Production of Artificial Liquid Fuels] color scale. The scale for rating varnish deposits on aluminum pistons consists of 11 color standards, ranging from light gray, which corresponds to the color of the clean piston and is rated zero, to black, which is represented by 10 points. The colors of the varnish deposits on the piston skirt and in the ring zone were rated separately.

To evaluate the deposits, the ring zone is broken up into nine belts (two belts for the crown and one each for the lands and grooves). Circumferentially, each belt is divided into ten segments. The result is determined as the arithmetic mean value. The rating is given in points and is reproducible to within ±10%.

The color Ts_{yu} of the deposits on the piston skirt is determined in the same way as the above index and is reproducible to within ±20%. The piston skirt is divided into five belts.

In addition, the quality of the oil was evaluated on the basis of the following indices:

the amount of deposits K_o on the piston in g, reproducibility ±30%;

clogging of holes in oil-control rings and piston drainage holes Z_{mk} in points – from 0 (clean) to 10 (completely blocked), reproducibility ±30%;

wear index I_i in points, reproducibility ±30%;

wear of top ring C_{vk}, in g, reproducibility ±40%;

corrosion index I_k in points, reproducibility ±10%;

the corrosive aggressiveness of the oil, determined visually and by weighing plates of type S-1 lead (k_{S-1}), SOS 6-6 lead babbitt ($k_{SOS\ 6-6}$), SB-30 lead bronze (k_{SB-30}), and ASM aluminum alloy (k_{ASM}), in g/m², reproducibility ±30%;

the stability index I_{sm} of the oil in points, reproducibility ±20%;

the increase U_v in oil viscosity, determined as a percentage at 50°C, reproducibility ±15%.

The indicators listed above are determined by the formulas

$$И_м = И_о + И_и + И_к + И_{св}$$
$$И_о = к_1 \cdot П_к + к_2 \cdot Н_{зк} + к_3 \cdot Ц_{зк} + к_4 \cdot К_о + к_5 \cdot З_{мк}$$
$$И_и = к_6 \cdot C_{вк}$$

Table 2. Results of Tests of AS-6 Oil with Control, Standard Method

a Сорт масла: b по классификации СССР	a Сорт масла: c по международной классификации	d Присадка	e Содержание присадки, вес. %	f Моторный индекс, баллы	g Показатели, входящие в моторный индекс: h Индекс отложений, баллы	h₁: i	h₁: j	h₁: k
u Базовое МА	v Регулярное	—	—	16	15	4.8	8.6	5 4
	x Премиум	y Монто-613; aa Сантолюб-493	0.7; 0.7	11.5	11	3.5	7.2	2
bb МБ	cc Хеви-Дьюти	y Монто-613; aa Сантолюб-493	1.5; 0.7	8.2	7.2	1.5	6	0
dd МВ	ee Серия 1	y Монто-613; aa Сантолюб-493	4; 0.25	5.3	4.8	1	3.8	0
МБ	cc Хеви-Дьюти	ff ВНИИ НП-360; hh АЗНИИ-ЦИАТИМ-1	3.5; 1	8.3	7.2	2	5	1
МА	x Премиум	ii СК-11; hh АЗНИИ-ЦИАТИМ-1	8; 1	11.3	9.8	2.5	7.2	0
МБ	cc Хеви-Дьюти	kk ЦИАТИМ-339; ll ПМС"Я"; mm ПМК-Д; nn ПМС-200А	1; 0.5; 0.3; 0.005	6.1	5.5	1	4.6	0
МВ	ee Серия 1	kk ЦИАТИМ-339; ll ПМС"Я"; mm ПМК-Д; nn ПМС-200А	1.5; 0.75; 0.3; 0.005	5.5	5.2	1	4.4	0
МБ	cc Хеви-Дьюти	qq АСК; rr ДФ-11; mm ПМК-Д; nn ПМС-200А	1.5; 1.2; 0.3; 0.003	7.8	7.2	1.3	5.7	0
МВ	ee Серия 1	qq АСК; rr ДФ-11; mm ПМК-Д; nn ПМС-200А	2.5; 1.2; 0.3; 0.003	5	4.6	1	3.7	0

*Plates of S-1, SOS 6-6, SB-30, and ASM.

(a) Oil type
(b) in USSR classification
(c) in international classification
(d) additive
(e) additive content, % by weight
(f) motor index, points
(g) indicators included in motor index
(h) deposits index, points
(h₁) indicators included in deposits index
(i) ring mobility, points
(j) color of deposits in ring zone, points
(k) color of deposits on piston skirt, points
(l) amount of deposits on piston, g
(m) clogging of holes in oil control rings, points
(n) wear index, points
(o) top-ring wear, g
(p) corrosion index, points
(q) plate corrosion, g/m²*
(r) stability index of oil, points
(s) 50°C viscosity increase, %
(t) remarks

and Recommended Additive Compositions on IKM-1 Machine by IKM-10FG

h l	m	n	o	p	q	r	s	t
1.1	3.2	0.1	0.008	0	2	0.9	17.8	
0.48	0.5	0	0.001	0	4	0.5	9.6	z Эталон
0.4	0	0.1	0.002	0	4	0.5	9.3	»
0.36	0	0.1	0.002	0	2	0.4	7.4	»
0.54	0	0.1	0.003	0	4	0.9	10.4	gg По ГОСТ 10541—63
0.61	0	1	0.002	0	1	0.7	13.9	jj НАМИ, отчет № 7068
0.31	0	0.1	0.002	0	3	0.6	12.1	oo Оптимальная рекомендуемая композиция
0.17	0	0	0.001	6	2	0.3	5.2	pp То же
0.43	0	0.1	0.002	0	1	0.6	12.9	»
0.31	0	0.1	0.005	0	2	0.3	6.4	»

(u) base
(v) regular
(w) MA
(x) premium
(y) Monto 613
(z) control
(aa) Santolube 493
(bb) MB
(cc) Heavy Duty
(dd) MV
(ee) series 1
(ff) VNII NP-360

(gg) according to GOST 10541-63
(hh) AzNII-TsIATIM-1
(ii) SK-11
(jj) NAMI, Report No. 7068
(kk) TsIATIM-339
(ll) PMS'Ya
(mm) PKM-D
(nn) PMS-200A
(oo) optimum recommended composition
(pp) same
(qq) ASK
(rr) DF-11

$$M_x = \kappa_7 \cdot (\kappa_{C-1} + \kappa_{OCe} + \kappa_{CS} + \kappa_{ACS})$$
$$M_{cs} = \kappa_8 \cdot Y_8$$

In these formulas, the conversion factors k have the values

$$\kappa_1 = 0.25 \quad \kappa_2 = 0.25 \quad \kappa_3 = 0.2 \quad \kappa_4 = 0.01$$
$$\kappa_5 = 1 \quad \kappa_6 = 3 \quad \kappa_7 = 25 \quad \kappa_8 = 0.05$$

The test method developed, which is known as the IKM-10FG method, is intended for use in determining the operational properties of Premium, Heavy Duty, and Series 1 oils and obtaining differential ratings of oils in these groups.

The results of tests run with AS-6 oil containing control, standard and other additive compositions on the IKM-1 apparatus using the IKM-10FG method (Table 2) were compared with the results of tests of the same oils with Monsanto additives (used as controls in this case) by the UR 176/60T method on a Pitter W-1 engine (Table 3).

The result of this comparison was full agreement of the data, with sharper differentiation of oils in the above groups (series) by the IKM-10FG method.

Good agreement was also observed when we compared our results with those of studies carried out in other organizations [The Automobile and Automotive Engine Scientific Research Institute (NAMI), the Moscow Small-Displacement Automobile Plant (MZMA), and VNII NP].

All of the above justifies the conclusion that oil tests by the IKM-10FG method on the IKM-1 bench conform to the level of the international standards.

Work was also done to study the functional properties of certain additives and adjust their compositions on the basis of commercial additives. Using the IKM-1 machine, for example, we studied the influence of organosilicon compounds: an alkylpolysiloxane fluid of the PMS-200A additive type, TsIATIM-339, PMS'Ya, ASK, and DF-11 additives, and combinations thereof. The following additive compositions were tested: AS-6 + 1% TsIATIM-339 + 0.5% PMS'Ya + PMS-200A; AS-6 + 3.5% VNII NP-360 + 1% AzNII-TsIATIM-1 + PMS-200A.

The test results (Fig. 2) show that the addition of very small amounts (0.003-0.005%) of the organosilicon compounds to the oils improves their use properties conspicuously.

Tests on a DK-2 machine established that when PMS-200A additive is used in the oil in combination with VNII NP-370 and PMS'Ya additives, the amount of condensation products formed by oxidation of the oils is reduced substantially.

Table 3. Results* of Tests of Soviet Oils from Eastern Petroleums

a Показатель	b (group of oil and additive composition)						
	c Базовое (регулярное)			e MA (Премиум) + 0,7% Монто-613 + 0,7% Сантолюб-493	f MB (Хеви-Дьюти) + 1,5% Монто-613 + 0,7% Сантолюб-493		g MV (Серия 1) + 4% Монто-613 + 0,25% Сантолюб-493
	d образец 1	d образец 2	d образец 3		d образец 1	d образец 2	
h Оценка, баллы:							
j юбка поршня	6.8	7.2	7.2	9.6	9.6	9.8	9.8
j гребень поршня	3.8	4.0	4.0	9.0	8.2	9.5	8.3
Потеря массы подшипника из k свинцовистой бронзы, мг	422	448	448	6	3	13	4
Увеличение вязкости при 37,8 °C, % l	67.7	57.5	57.5	47.5	40.1	47.1	46.1

*Obtained by Monsanto by JP 176/60T method on Pitter W-1 engine.

KEY: (a) indicator; (b) group (series) of oil and additive composition; (c) base (regular); (d) specimen... (e) MA (premium) + 0.7% Monto 613 + 0.7% Santolube 493; (f) MB (Heavy Duty) + 1.5% Monto 613 + 0.7% Santolube 493; (g) MV (series 1) + 4% Monto 613 + 0.25% Santolube 493; (h) rating, points; (i) piston skirt; (j) piston crown; (k) mass loss of lead-bronze bearing, mg; (l) viscosity increase at 37.8°C, %.

The color of the deposits in the piston-ring zone was 6.9 points on the VNII NP scale in a test of AS-6 oil with 1% of TsIATIM-339 additive and 0.5% PMS'Ya, but when 0.005% of PMS-200A was added to the same mix, it was lowered to 4.6 points. The same result was obtained on introduction of 0.005% of PMS-200A into an additive mix consisting of 3.5% VNII NP-360 and 1% AzNII-TsIATIM-1 in AS-6 oil. In this case, the color of the deposits in the piston-ring zone is lowered from 8 to 5.8 points. This makes it possible to bring GOST 10541-63 group MB oils up to the level of group MV, improves piston-ring working conditions, and reduces piston deposits.

The thermal stability of oil with these additive mixes was also improved, as is clearly indicated by the decrease in the rate of viscosity change in tests of the oil on the IKM-1 machine. For example, while the additive mix consisting of 1% TsIATIM-339 and 0.5% PMS'Ya caused a 13.9% viscosity increase in AS-6 oil, this increase was only 5.6% when 0.005% of PMS-200A was added.

On introduction of the additive mix consisting of 3.5% VNII NP-360 and 1% AzNII-TsIATIM-1 into AS-6 oil, viscosity increases by 18.1%; with simultaneous addition of PMS-200A, the viscosity increases by only 5.4%.

This improvement of the use properties of the oil on introduction of the chain-stopping additive into a mix containing

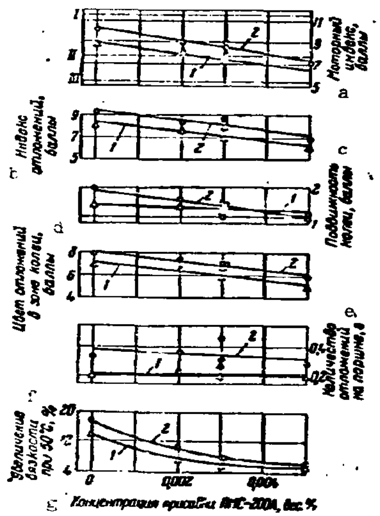

Fig. 2. Influence of content of PMS-200A additive on motor properties of AS-6 oil with the following additive compositions: 1) AS-6 + 1% TsIATIM-339 + 0.5% PMS'Ya + + PMS-200A; 2) AS-6 + 3.5% VNII NP-360 + 1% AzNII-TsIATIM-1 + PMS-200A. I) Level of group MA control oil; II) same, group MB; III) same, group MV.
KEY: (a) motor index, points; (b) deposits index, points; (c) ring mobility, points; (d) color of deposits in ring zone, points; (e) quantity of deposits on piston, g; (f) increase in viscosity at 50°C, %; (g) concentration of PMS-200A additive, % by weight.

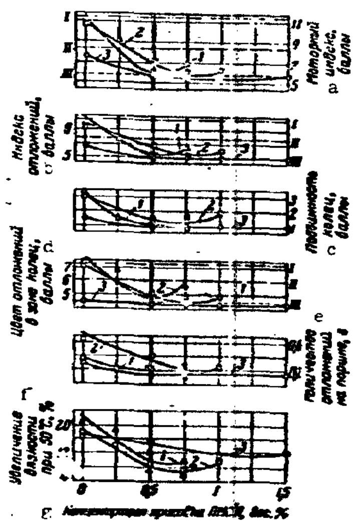

Fig. 3. Influence of content of PMS'Ya additive on motor properties of AS-6 oil with the following additive compositions: 1) AS-6 + 1% TsIATIM-339 + PMS'Ya + 0.005% PMS-200A; 2) AS-6 + 1.5% TsIATIM-339 + PMS'Ya + 0.005% PMS-200A; 3) AS-6 + 2.5% TsIATIM-339 + PMS'Ya + 0.005% PMS-200A. I) Level of group MA control oil; (II) same, group MB; III) same, group MV.
KEY: (a) motor index, points; (b) deposits index, points; (c) ring mobility, points; (d) color of deposits in ring zone, points; (e) quantity of deposits on piston, g; (f) increase in viscosity at 50°C, %; (g) concentration of PMS'Ya additive, % by weight.

detergent and antioxidant components can be explained by the decreased aeration of the oil, which has a strong influence on quality changes of oil in the engine.

A test of TsIATIM-339 additive in concentrations of 1.0, 1.5, and 2.5% in a mix with 0.005% PMS-200A indicated (Fig. 3) that the amount of piston deposits decreases from 0.65 to 0.32 g, ring mobility from 1.5 to 1 point, and the color of the deposits in the piston-ring zone from 7.2 to 4.5 points as the concentration of the TsIATIM-339 additive is increased to 2.5%. In this case, the motor index drops from 11 points (the level of the group MA control oil) to 7.5 points, which corresponds to the level of MB control oil. As the test results showed, the tested concentrations of TsIATIM-339 additive do not provide adequate detergent properties in the oil, and for this reason they were supplemented with PMS'Ya detergent-dispersing additive in concentrations of 0.25, 0.5, 0.75, 1, 1.25, and 1.5% by weight.

On introduction of small amounts of the new additive mixes, ring mobility drops to 1 point, the color of deposits in the piston-ring zone to 4.2-4.5 points, the amount of piston deposits to 0.16-0.2 g, and the rate of oil viscosity increase after the test to 5-8%. In this case, the motor index declines to 5.5-6 points, which corresponds to the level of the group MV control oil (series 1). However, it must be noted that the optimum values can be obtained only at definite proportions of the TsIATIM-339 and PMS'Ya additives, in the 2:1 range. This ratio also applies for diesels operated on low-sulfur fuels (Fig. 4). Departure from it results in a rise of the motor index, indicating deteriorating oil quality.

Adjustment of the mix on the basis of the TsIATIM-339, PMS'Ya, polymethacrylate D (for winter-grade oils), and PMS-200A additives, which was carried out on the IKM-1 machine by the IKM-10FG method, resulted in tentative recommendations of oils conforming to the Premium, Heavy-Duty, and Series 1 groups. The results of tests on these oils were compared with those for oils with the imported control additives Monto 613 and Santolube 493.

The above additive mixes were also tested on a machine with a full-scale Moskvich 407 automobile engine, and the correctness of the results obtained was confirmed.

Thus, the additive mix given in Table 4 can be recommended on the basis of the tests for oils for carburetor-type automobile engines.

Tests of another additive mix, consisting of ASK, DF-11, polymethacrylate D (for winter oils) and PMS-200A in AS-6 oil were run by the IKM-10FG method on the IKM-1 installation. The content of the ASK additive in the mix was varied from 1.5 to 3.5%. As the tests showed (Fig. 5), as little as 1.5% of ASK produces an oil conforming to group MB (Heavy Duty); when the ASK concentration is increased to 2.5%, group MV (Series 1) oils

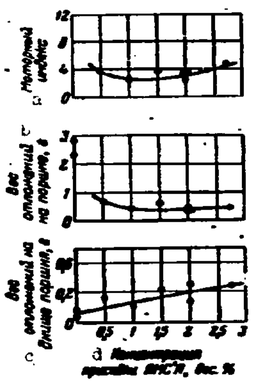

Fig. 4. Influence of content of PMS'Ya additive on motor properties of oil with additive mix consisting of 3% TsIATIM-339, PMS'Ya, and 0.005% PMS-200A.
KEY: (a) motor index; (b) weight of deposits on piston, g; (c) weight of deposits on piston head, g; (d) PMS'Ya additive concentration, % by weight.

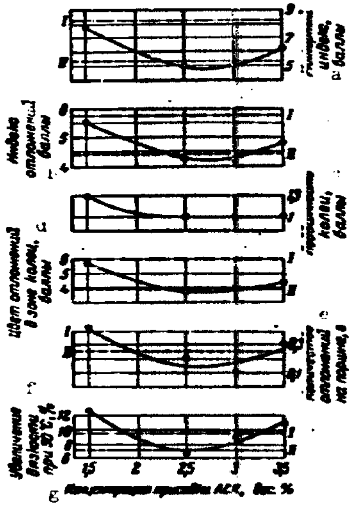

Fig. 5. Influence of ASK additive content on motor properties of AS-6 oil with additive composition consisting of ASK, 1.2% DF-11, 0.3% PMM-D, and 0.003% PMS-200A. I) level of group MB control oil; II) same, group MV.
KEY: (a) motor index, points; (b) deposits index, points; (c) ring mobility, points; (d) color of deposits in ring zone, points; (e) amount of deposits on piston, g; (f) viscosity increase at 50°C, %; (g) ASK additive concentration, % by weight.

are obtained. Here the color of the piston deposits drops from 5.7 to 3.7 points on the VNII NP scale, the amount of deposits on the piston is reduced from 0.43 to 0.1-0.2 g, and the degree of viscosity increase also drops from 12.9 to 6.4%. The decrease in the motor index from 7.8 to 5 points also indicates an improvement of the operational properties of oil with these additives.

Table 4. Recommend[illegible] Additi[illegible] Mi[illegible]

Присадка	Содержание присадки, вес. %		
	группа масла		
	МА	МБ	МВ
ЦИАТИМ-339	0.[illegible]–1	1–1.5	1.5–2
ИМСЯ	0.2–0.5	0.75–1	1–1.5
Полиметакрилат Д (для зимних масел)	0.3	0.3	0.3
ПМС-200А	0.005	0.005	0.005

KEY: (a) additive; (b) [illegible] [illegible]ntent, % by weight; (c) oil group; (d) [illegible]; (e) MV; (f) TSIATIM-339; (g) [illegible]; (h) [illegible] polymethacrylate D (for winter-grade [illegible]); (i) PMS-[illegible]A.

Table 5. Recommended [illegible]

Присадка	Содержание присадки, вес. %	
	группа масла	
	МБ	МВ
АСК	1–1.5	1.5–2.5
ДФ-11 или ВНИИ НП-354	0.6–1.2	0.6–1.2
Полиметакрилат Д (для зимних масел)	0.3	0.3
ПМС-200А	0.003	0.003

KEY: (a) additive; (b) additive content, % by weight; (c) oil group; (d) MB; (e) MV; (f) ASK; (g) DF-11 or VNII NP-354; (h) polymethacrylate D (for winter-grade oils); (i) PMS-200A.

Increasing the concentration of ASK additive to 3.5% in this mix is quite detrimental to the properties of the oil (see Fig. [illegible]). The deposits index rises from 4.[illegible] to 5.6 points and the motor index from 5 to 6.2 points.

Oils with these additive mixes were bench-tested in a full-sized Moskvich 407 automobile engine. The test results showed that the quality of the recommended oils is somewhat higher than that of the group MB (Heavy Duty) and MV (Series 1) control oils.

The test results are a basis for recommending one more additive mix (in % by weight) for oils used in carburetor-type automobile engines (Table 5).

CONCLUSIONS

1. A method designated IKM-10FG was developed for motor rating of the use properties of base oils and additive oils of groups MA (Premium), MB (Heavy Duty), and MV (Series 1) by short-term (16-hour) tests on a special [illegible] designated IKM-1.

[illegible] The IKM-10FG method [illegible] [illegible]nd[illegible] oils by [illegible] MA, MB, and MV, to determine [illegible] properties of individual additives, and [illegible] optimum additive [illegible] in such a way as to produce [illegible] the respective [illegible].

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Symbol List

Manuscript page	Symbol	English Equivalent
[illegible]	[illegible]	motor
[illegible]	[illegible]	deposit
	k	ring
	Tc	color
	rk	ring zone
	[illegible]	skirt
	[illegible]	clogging
	[illegible]	oil control
	[illegible]	index
	[illegible]	wear
	[illegible]	top ring
	[illegible]	corrosion
	[illegible]	oil stability
	[illegible]	increase
	[illegible]	viscosity

TESTS OF SOVIET AND FOREIGN MOTOR OILS IN THE UIM-6-NATI AND UIM-6N-NATI SINGLE-CYLINDER BENCH INSTALLATIONS

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The object of the study reported in this paper was to design a single-cylinder bench installation based on a series-produced supercharged tractor diesel, develop a test method, and rate various types of motor oils.

The properties of oils intended for work under relatively light-duty conditions (Premium type) have been rated on the UIM-3 single-cylinder bench built at the Automobile and Automotive Engine Scientific Research Institute (NATI) on the basis of the D-54 tractor diesel. Later, the UIM-6-NATI machine was developed on the basis of the D-75 tractor diesel, which is a supercharged modification of the D-54, for testing Heavy Duty and Series 1 oils.

For rating Series 2 oils, the apparatus was fitted with a supercharging unit that delivered a substantial increase in horsepower per liter; this installation was designated UIM-6N-NATI (see figure).

Below we list the technical data of the UIM-6-NATI and UIM-6N-NATI installations.

	UIM-6-NATI	UIM-6N-NATI
Power, hp..................	[illegible]	30
Crankshaft speed, rev/min..	[illegible]	1500
Mean effective pressure, kg/cm^2..................	[illegible]	9.7
Horsepower per liter.......	[illegible]	16.1
Compression ratio..........	[illegible]	16
Bore, mm...................	125	125
Stroke, mm.................	152	152
Boost pressure, kg/cm^2.....	—	0.5
Mixing.....................	Swirl chamber	
Fuel consumption, kg/hour..	[illegible]	6
Lubrication system capacity, kg..................	[illegible]	5
Specific lubricating system capacity, kg/hp.........	[illegible]	0.17
Conventional heat-load index of cylinder-piston group...................	[illegible]	71
Conventional oil-duty index....................	[illegible]	426
Lubricating system.........	Single-circuit with wet sump	
Cooling system.............	Double-circuit	
Coolants...................	Water for cylinder head, glycerine for cylinder sleeve	

The basic data of the UIM-6-NATI bench make a close approach to those of the SMD-14, AM-01 and other modern tractor diesels, and those of the UIM-6N-NATI simulate those of the supercharged SMD-19 and YaMZ-238NB tractor diesels.

In developing the method for rating the motor properties of crankcase oils from their tendency to form carbon deposits, we chose engine operating conditions under which the type and degree of parts fouling by deposits formed in full-scale engines during long-term use could be duplicated during a relatively short test time.

TEMPERATURE MEASUREMENTS ON THE ENGINE

The temperature condition of the components of the cylinder-piston group has a strong influence on the process of deposit formation in an engine; for this reason, temperature readings were taken at the sleeve and piston of the UIM-6-NATI installation under various engine operating conditions.

It was established that the highest piston-head temperature (at the center of the combustion chamber) in operation without supercharging and at an effective pressure of $P_e = 6.8$ kg/cm^2 is [illegible], while that on the side of the piston head is 20°C lower. The temperatures in the areas of the first and second grooves are [illegible] and 182°C, respectively. Boosting causes no substantial

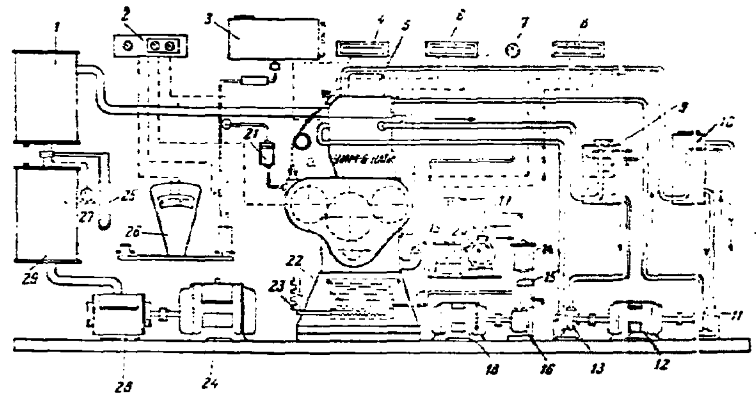

Fig. 1. Diagram of UIM-6N-NATI bench installation for motor-oil testing. 1, 19, 29) receivers; 2) instrument for measuring fuel flow rate (PSID-ZM-NATI); 3) fuel tank; 4, 6, 8) lagometers [sic]; 5) engine; 9) heat exchanger; 10) mixing tank; 11, 13) water pumps; 12, 18, 24) electric motors; 14) oil filter; 15) reduction valve; 16) oil pump; 17) oil radiator; 20) gas meter; 21) fuel filter; 22) oil sump; 23) LATR [lab autotransformer]; 25) piezometer; 26) scales; 27) thermistor; 28) supercharger. KEY: (a) UIM-6-NATI.

change in the temperature distribution on the piston and cylinder sleeve; at $P_e = 9.5$ kg/cm^2, the temperature rises by only 10-12°C.

Similar results, which are presented on page 65, were obtained on the SMD-14, AM-01, SMD-18, and YaMZ-238NV [sic] engines. When glycerine was used as a coolant instead of water, the temperatures of the engine parts rise sharply. For the first and second piston grooves, this temperature increase is 55°C.

Piston temperature increases by 0.5°C on a 1°C increase in the glycerine temperature.

INFLUENCE OF ENGINE TEMPERATURE CONDITIONS ON RATE OF CARBON-SCALE FORMATION

It has been established [1] that the rate of fouling of engine parts is determined in many respects by engine-temperature conditions and test time; the test time can be shortened by increasing the heat load on the engine parts. However, [illegible]

	УИМ-6-НАТИ	СМД-14	АМ-01	УИМ-6Н-НАТИ	СМД-18	ЯМЗ-238НБ
Мощность, л. с.	21	75	110	30	92	210
Скорость вращения коленчатого вала, об/мин	1500	1700	1600	1500	1700	1700
Среднее эффективное давление, кГ/см²	6.8	6.3	5.6	9.7	7.8	7.5
л. с./л	11.3	11.5	9.9	16.4	15	15
Давление наддува, кГ/см²	—	—	—	0.5	0.35	0.25
Удельная емкость системы смазки, кг/л. с.	0.24	0.25	0.22	0.17	0.21	0.13
Условный показатель тепловой напряженности цилиндро-поршневой группы	53.2	49.2	40.5	71	60.5	55.4
Условный показатель напряженности работы масла	212	192	192	436	292	430
Температура поршня, °C						
Первая канавка						
$t_в = 95$ °C	218	198	—	227	215	230
$t_{глицер.} = 115$ °C	272	—	—	282	—	—
Вторая канавка						
$t_в = 95$ °C	180	157	—	193	177	205
$t_{глицер.} = 115$ °C	244	—	—	253	—	—

KEY: (a) UIM-6-NATI; (b) SMD-14; (c) UIM-6N-NATI; (d) YaMZ-238NB; (e) horsepower; (f) crankshaft speed, rev/min; (g) mean effective pressure, kg/cm²; (h) hp/liter; (i) boost pressure, kg/cm²; (j) specific lubrication-system capacity, kg/hp; (k) conventional heat-load index of cylinder-piston group; (l) conventional oil duty index; (m) piston temperature, °C; (n) first groove; (o) second groove.

sharp increase in engine thermal conditions may change the direction of physicochemical conversions in the oil and cause rapid coking of the piston rings, with the result that objective rating of the oil's quality is distorted.

Therefore, taking a 120-hour test time, which corresponds to the average oil-change interval in tractor engines, we tested Heavy Duty oil at a water-coolant temperature of 95°C and glycerine temperatures of 95, 115, and 135°C to find the optimum thermal regimes on the UIM-6-NATI bench. The test results in Table 1 indicate that scaling on the piston increases substantially as running temperatures rise, especially when we pass to the 115°C glycerine temperature, and the over-all piston-fouling rating reaches 16.2 points.

When the glycerine temperature rises to 135°C, the rate of deposit accumulation decreases and the over-all rating rises only 3 points.

Table 1. Influence of Coolant Temperature on Rate of Piston Fouling

a Показатели	b (УИМ-6-НАТИ) c вода при 95 °C	d глицерин при 95 °C	при 115 °C	при 135 °C	e (Series 1) c вода при 95 °C	d при 115 °C	при 135 °C	f (Series 2) при 95 °C	при 115 °C	при 135 °C
Потеря подвижности поршневых колец, баллы**	0	0	0	0	0	0	6	[illegible]	0	1
Нагароотложение в поршневых канавках, баллы***	1.25	1.9	11.2	12.1	3.7	7.1	16	0.7	10	7
Суммарная оценка нагароотложения на поршне, баллы****	1.7	3.4	16.2	19.0	4.5	9.8	29.6	1.0	12	10
Количество отложений в канавках и на поршне, г	0.5	0.9	2.2	2.5	0.9	1.1	3.9	0.2	2.2	1.6

*By UIM-6-NATI method.
**Rated in points as a function of the degree of mobility of each piston ring. Here the condition of a ring that can be moved freely in its groove is given a point rating of 0; the condition of a ring that is coked around its entire circumference is given a rating of 10.
***Rated in points as a function of the amount and type of deposits (semifluid, hard, etc.) in each groove. A perfectly clean groove is given a rating of 0; a groove completely filled with solid deposits is rated 10.
****The point ratings characterizing the fouling of all piston zones are totaled. In this table and in Tables 2, 3, and 6, the indicators (in points) characterizing the presence of deposits on the piston skirt, on the inside surface of the piston, etc., are not listed, although they are included in the over-all rating.
KEY: (a) indicators; (b) Heavy Duty (UIM-6-NATI); (c) water; (d) glycerine; (e) Series 1 (UIM-6N-NATI); (f) Series 2 (UIM-6N-NATI); (g) at; (h) loss of piston-ring mobility, points**; (i) carbon scaling in piston grooves, points***; (j) over-all carbon scaling rating for piston, points****; (k) amount of deposits in grooves and on piston, g.

Similar results were obtained in tests of Series 1 and Series 2 oils on the UIM-6N-NATI benches at various coolant temperatures. In the tests of Series 2 oil, going from 115 to 135°C is detrimental to the mobility of the first compression ring and reduces piston fouling slightly, probably because of burning-out of the deposits in the ring grooves.

On the basis of the results obtained on piston fouling and the physicochemical properties of the used oils, the coolant (glycerine) temperature was set at 115°C. At this temperature, Heavy Duty and Series 1 oils are differentiated quite sharply on the UIM-6-NATI machine (16.2 and 9.8 points, respectively); at the same temperature, the over-all piston-scaling figures obtained on the UIM-6N-NATI bench for Series 1 and Series 2 oils differ even more widely (29.5 and 12 points, respectively); also, the first compression ring was coked after 60-80 hours of the test on Series 1 oil.

Thus, the test conditions arrived at made it possible to classify Heavy Duty, Series 1, and Series 2 oils clearly and reliably.

REPRODUCIBILITY OF TEST RESULTS

One of the important stages in developing an oil-test method is to check the reproducibility of the results of parallel experiments.

Table 2. Results of Parallel Tests on Heavy Duty and Series 1 Control Oils

a Показатели (в баллах)	b Хеви-Дьюти						c Серия 1			
	d содержание серы в топливе, %									
	0.2		0.9							
e Потеря подвижности поршневых колец	0	0	0	0	0	0	0	0	0	0
f Нагароотложение в первой поршневой канавке	1.4	4.7	10	8.3	9.3	9.2	5.1	4	4.6	4.8
g Нагароотложение в остальных канавках	1.1	0.3	3.1	2.9	1.4	3.4	2	1.7	1.1	2.5
h Суммарная оценка нагароотложения на поршне	4.8	6.6	15.4	16.2	15.8	13.8	9.8	8.4	7.9	9.9

KEY: (a) indicator (in points); (b) Heavy Duty; (c) Series 1; (d) sulfur content in fuel, %; (e) piston ring mobility loss; (f) scaling in first ring groove; (g) scaling in other grooves; (h) over-all piston-scale rating.

For this purpose, repeated tests were made with Heavy Duty, Series 1, and Series 2 oils both on the same installation and on several installations at the NATI, the All-Union Scientific Research Institute of Oil and Gas Processing and Production of Artificial Liquid Fuel (VNII NP), the Bashkir Scientific Research Institute of Petroleum Refining (BashNII NP), and the Institute of Petrochemical Processes (INKhP AN) of the Azerbaydzhan SSR.

The test results, which appear in Tables 2 and 3, indicate satisfactory agreement between the results of the tests on all oil types.

Table 3. Results of Parallel Tests of Series 2 Control Oil

a Показатели (в баллах)	b НАТИ		c ВНИИ НП		d БашНИИ НП		e ИНХП АН Азерб. ССР	
	I	II	I	II	I	II	I	II
f Потеря подвижности поршневых колец	0	0	0	0	0	0	0	0
g Нагароотложение в первой поршневой канавке	6.7	7.0	5.5	9.8	9.4	8.9	8.3	6.0
h Нагароотложение в остальных канавках	1.6	3.0	3.2	0.9	0.7	0.6	2.1	2.3
i Суммарная оценка нагароотложений на поршне	10.5	14.4	11.2	12.1	10.9	11.2	13.2	11.0

KEY: (a) indicators (in points); (b) NATI; (c) VNII NP; (d) BashNII NP; (e) INKhP AN Azerb. SSR; (f) loss of piston-ring mobility; (g) scaling in first ring groove; (h) scaling in other grooves; (i) over-all piston-scale rating.

COMPARISON OF OIL-TEST RESULTS OBTAINED ON SINGLE-CYLINDER BENCH AND ON TRACTOR DIESELS

In many cases, the results of oil tests on certain laboratory and motor machines do not agree with results obtained on full-sized production engines. This is chiefly because the operating and test conditions set up on the laboratory and motor installations do not match the design features and operating conditions of the production engines.

To one degree or another, almost all of the methods that have been developed permit classification of oils, but many of them have not been used extensively because tests of the same oils in engines give inconsistent results. Hence the basic criteria for establishing the reliability of the results should be the results obtained in long-term tests of the same oil specimens on the most common types of engines.

Tests were run on Heavy Duty (with low-sulfur and sulfur-containing fuels) and Series 1 control oils on the UIM-6-NATI bench and in SMD-14 and D-28 tractor diesels in order to determine the reproducibility of the results.

The indicators listed in Table 4 indicate that the high-temperature test regime selected for the UIM-6-NATI bench, which made it possible to reduce the test time to 120 hours, enables us to obtain the same results as with production engines operating under normal temperature conditions for 500 hours. The UIM-6-NATI installation occupies an intermediate position between the SMD-14 and D-28 engines as regards almost all indicators of piston and ring fouling by carbon deposits.

Table 4. Results of Tests on Control Oils in UIM-6-NATI Bench and D-28 and SMD-14 Engines

a Показатели	b Хеви-Дьюти						c Серия 1		
	d содержание серы в топливе, %								
	0,2			0,9					
	e УИМ-6-НАТИ	f Д-28	g СМД-14	e УИМ-6-НАТИ	f Д-28	g СМД-14	e УИМ-6-НАТИ	f Д-28	g СМД-14
h Потеря подвижности поршневых колец, баллы	0	0	0	0	0	0	0	0	0
i Нагароотложение, баллы									
j в первой поршневой канавке	2.6	2.6	1.0	9.2	7.6	7.0	4.8	3.7	1.8
k в остальных поршневых канавках	1.3	1.7	1.1	2.4	4.4	0.9	1.8	3.3	1.2
l на перемычках	1.1	2.0	1.7	2.0	5.6	3.6	1.6	2.7	1.3
m на юбке поршня	0.7	0.2	0.9	1.1	0.9	2.5	0.8	0.3	0.2
n в прорезях маслосъемных колец и дренажных отверстиях днища поршня	0.3	0.8	0.3	0.7	1.0	0.5	0.5	0.8	0.3
o Суммарная оценка, баллы	6.3	8.3	6.0	16.4	21.3	16.6	9.5	11.5	4.8
p Количество отложений в первой поршневой канавке и на кольце, г	0.43	1.15	0.22	1.96	2.13	1.35	0.97	0.59	0.33
q Количество отложений во всех канавках и на всех кольцах, г	0.55	1.67	0.68	2.20	3.18	2.03	1.20	1.61	0.41

KEY: (a) indicator; (b) Heavy Duty; (c) Series 1; (d) sulfur content in fuel, %; (e) UIM-6-NATI; (f) D-28; (g) SMD-14; (h) loss of piston-ring mobility, points; (i) scaling, points; (j) in first ring groove; (k) in other ring grooves; (l) on lands; (m) on piston skirt; (n) In slots of oil-control rings and drainage holes in head of piston; (o) over-all rating, points; (p) amount of deposits in first ring groove and on ring, g; (q) amount of deposits in all grooves and on all rings, g.

The results of the quick (120-hour) tests run on various samples of domestic oils with the "UIM-6N-NATI installation also agree closely with the results obtained in long-term (800-hour) tests on the turbosupercharged SMD-18 and YaMZ-238NB tractor engines (Table 5).

Table 5. Results of Oil Tests on IM-6N-NATI [sic] Installation and SMD-18 and YaMZ-238NB Engines

a Показатели	b Масло ДС-11 с присадками							
	c 5% ВНИИ НП-370 + 2% ПМС"Я + 0,5% ЛЗ-23к + 0,005% ПМС-200А			d 3% ЦИАТИМ-339 + 2% ПМС"Я + 0,003% ПМС-200А			e 11% ВНИИ НП + 4% ПМС"Я + 0,5% ЛЗ-23к + 0,005% ПМС-200А	
	f УИМ-6Н-НАТИ	g СМД-18	h ЯМЗ-238НБ	f УИМ-6Н-НАТИ	g СМД-18	h ЯМЗ-238НБ	f УИМ-6Н-НАТИ	g СМД-18
i Суммарная оценка нагароотложений, баллы	22.3	21.7	25	24.4	21	25.5	13.1	7.5
j Количество отложений в канавках и на кольцах, г	2.6	3.1	4.1	3.3	2.3	2.8	1.5	1
k Износ гильз, баллы	1	1.7	0.5	1	1.3	0.5	1	1.5

KEY: (a) indicators; (b) DS-11 oil with additives; (c) 5% VNII NP-370 + 2% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (d) 3% TsIATIM-339 + 2% PMS'Ya + 0.003% PMS-200A; (e) 11% VNII NP + 4% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (f) UIM-6N-NATI; (g) SMD-18; (h) YaMZ-238NB; (i) over-all scaling rating, points; (j) amount of deposits in grooves and on rings, g; (k) sleeve wear, points.

Thus, the conditions adopted for quick oil testing on the single-cylinder bench both with and without the pressure boost permit objective evaluation of Heavy Duty, Series 1, and Series 2 oils and make it possible to reduce substantially the amount of expensive long-term testing done on production engines.

TESTS OF OIL SAMPLES

Various samples of oils developed by the VNII NP, the BashNII NP, and the INKhP AN of the Azerbaydzhan SSR were tested on the UIM-6-NATI and UIM-6N-NATI installations under the conditions stated above.

The object of the tests was to establish conformity of the motor qualities of the tested oils to the qualities of the Heavy Duty, Series 1, and Series 2 control oils.

	Heavy Duty and Series 1	Series 2
Duration of tests, hours........	120	120
Effective engine output, hp.....	21	30
Fuel consumption, kg/h..........	4.5	5.0
Crankshaft speed, rev/min.......	1500	1500
Boost pressure, kg/cm^2..........	—	0.5
Temperatures, °C		
water coolant in cylinder head	90	90

glycerine in cylinder jacket	115	115
oil in crankcase	95	95

We see from the results obtained (Table 6) that DS-11 oil with 6% VNII NP-360 has properties similar to those of the Heavy Duty control oil.

DS-11 oil with 3% TsIATIM-339 and oil with 3% TsIATIM-339 + + 2% AFB have motor properties considerably below those of the Heavy Duty control oil. The same oil with the following additive mixes:

5% VNII NP-370 + 2% PMS'Ya + [illegible]% LZ-23k + 0.005% PMS-200A;
3% TsIATIM-339 + 2% PMS'Ya + 0.005% PMS-200A;
7.5% BFK + 2% SK-3 + 0.5% LZ-23k + 0.005% PMS-200A;
5% BFK + 2% SB-3 + 0.005% PMS-200A;
3% BashNII-2 + 1% PMS'Ya + 0.005% PMS-200A

has use properties approaching those of the Series 1 control oil, while DS-11 oil with an additive mix consisting of 3% TsIATIM-339 + 2% PMS'Ya and 0.05% PMS-200A has antiscaling properties slightly superior to those of the control oil.

The test results obtained on the single-cylinder bench unit were in full agreement with the results of long-term tests run on full-scale D-50 and SMD-14 tractor engines (see Table 6).

Tests run on the UIM-6N-NATI machine with DS-11 oil having the following additive mixes:

11% VNII NP-370 + 4% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A;
11% BFK + 4% SB-3 + 0.005% PMS-200A;
4% BashNII-2 + 4% PMS'Ya-200A [sic]

indicated (Table 7) that the properties of these oils can be equated to those of the Series 2 control oil; note should be taken of the high use properties of the oil with 4% BashNII-2 + + 4% PMS'Ya + 0.005% PMS-200A, which was given an over-all rating of 7 points as against 11.5 points for the control oil.

CONCLUSIONS

1. A general-purpose single-cylinder bench engine designated UIM-6-NATI and a supercharged modification, UIM-6N-NATI, were designed and built for evaluation of the use properties of various types of oils made for use in existing and projected tractor diesels.

2. A battery of tests was run to adjust test conditions and develop a technique for quick (1[illegible]-hour) tests of Heavy Duty, Series 1, and Series 2 motor oils.

3. The tests showed that the conditions selected permit sharp differentiation of the oils and produce satisfactory

Table 6. Results of Tests of Oils with Domestic Additives

a Показатели	b Масло ДС-11							
	c 0,7% Сантолюб-493+1,5% Монто-613 (Хеви-Дьюти)		d 6% ВНИИ НП-360			e 3% ЦИАТИМ-339		
	m УИМ-6-НАТИ	n СМД-14	m УИМ-6-НАТИ	o Д-50	n СМД-14	m УИМ-6-НАТИ	o Д-50	n СМД-14
p Потеря подвижности поршневых колец, баллы	0	0	—	—	—	3	3	6
q Нагароотложение в первой поршневой канавке, баллы	9.2	8	—	—	—	10	10	10
r Нагароотложение в остальных канавках, баллы	3.4	4.8	—	—	—	5	5.2	8
s Суммарная оценка, баллы	19.8	21.7	22	24	16	29	29	37.[illegible]
t Количество нагара на кольцах и в канавках, г	2.2	3.2	—	—	—	3.5	4.2	5.[illegible]
u Износ гильз, баллы	2	0.8	—	—	—	2.56	0.7	1.[illegible]
v Износ первого кольца, баллы	13	5.4	—	—	—	11.2	4.2	4.[illegible]
w Износ комплекта колец, г	1.1	2.4	—	—	—	1.9	1.7	2.[illegible]

a) indicator
b) DS-11 oil with additive
c) 0.7% Santolube 493 + 1.5% Monto 613 (Heavy Duty)
d) 6% VNII NP-360;
e) 3% TsIATIM-339
f) 3% TsIATIM-339 + 2% AFB
g) 2.5% Santolube 493 + 4% Monto 613 (Series 1)
h) 5% VNII NP-370 + 2% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A
i) 3% TsIATIM-339 + 2% PMS'Ya + 0.005% PMS-200A
j) 7.5% BFK + 2% SB-3 + 0.5% LZ-23k + 0.005% PMS-200A
k) 5% BFK + 2% SB-2 + 0.005% PMS-200A

on UIM-6-NATI Bench and D-50 and SMD-14 Engines

f 3% ЦИАТИМ-339 + 2% АФБ: m УИМ-6-НАТИ	f: n СМД-14	g 2.5% Сантолюб-493 + 4% Монто-613 (Серия 1): m УИМ-6-НАТИ	g: o Д-50	g: n СМД-14	h 5% ВНИИ НП-370 + 2% ПМС'Я + 0.5% ЛЗ-23к + 0.005% ПМС-200А: m УИМ-6-НАТИ	h: o Д-50	h: n СМД-14	i 3% ЦИАТИМ-339 + 2% ПМС'Я + 0.005% ПМС-200А: m УИМ-6-НАТИ	i: n СМД-14	j 7.5% БФК + 2% СБ-3 + 0.5% ЛЗ-23к + 0.005% ПМС-200А: m УИМ-6-НАТИ	j: n СМД-14	k [illegible] ПМС-200А: m УИМ-6-НАТИ	l: m УИМ-6-НАТИ
0	1.25	0	0	0	0	0	0	0	0	0	0	0	0
10	8.5	4.8	5.2	2.7	4.5	4.5	4.5	3.7	2.8	6	6.4	1.7	6.3
3.2	6.8	2.5	1.9	2.5	2	2.9	1.5	0.9	2.6	2.3	3	2.9	1
23.2	28	9.9	10.5	9.2	10.8	12	10.1	6.9	11	12	16.9	9.2	10.8
2.9	4.6	1.1	1.3	1	0.9	1.2	1.6	0.9	1.4	1.4	2.5	1.05	—
2.2	0.5	3.1	0.8	0.6	1.1	0.9	1.35	3	1.25	2.4	0.6	3	—
6.5	2.1	5.6	2.6	3.1	5.6	3.1	3.9	4.3	2.1	2.7	3.2	3.4	—
0.5	1.3	0.5	1.1	1.35	0.4	1.1	1.9	0.7	1.2	0.7	1.5	0.5	—

(l) 3% BashNII-2 + 1% PMS'Ya + 0.005% PMS-200A
(m) UIM-6-NATI
(n) SMD-14
(o) D-50
(p) piston-ring mobility loss, points
(q) carbon scaling in first ring groove, points
(r) carbon scaling in other grooves, points;
(s) over-all rating, points
(t) amount of scale on rings and in grooves, g
(u) sleeve wear, points
(v) first-ring wear, points
(w) wear of set of rings, g

Table 7. Results of Testing Series 2 Oils with Domestic Additives on UIM-6N-NATI Machine

a Показатели	b Масло ДС-11 с присадками: c с импортными присадками	d 11% ВНИИ НП-370 + 4% ПМС'Я + 0.5% ЛЗ-23к + 0.005% ПМС-200А	e 11% БФК + 4% СБ-3 + 0.005% ПМС-200А	f 4% БашНИИ-2 + 4% ПМС'Я + 0.005% ПМС-200А
g Потеря подвижности поршневых колец, баллы	0	0	0	0
h Нагароотложение, баллы:				
i в первой канавке	5.5	6.7	4.3	4
j в остальных канавках	3.5	2.4	3.3	0.8
k в перемычках	1.4	2.7	3.1	0.9
l на юбке поршня	0.6	0.6	0.8	0.8
m на внутренней поверхности поршня	0.5	0.7	0.5	0.5
n в дренажных отверстиях и прорезях маслосъемных колец	0	0	0	0
o Суммарная оценка, баллы	11.5	13.1	12.0	7
p Количество нагара в канавках и на кольцах, г	1.5	1.4	1.1	1.1
q Износ гильз, мк	9	5.2	6.3	10.4
r Износ комплекта колец, г	0.9	0.8	0.7	0.7

KEY: (a) indicator; (b) DS-11 oil with additives; (c) with imported additives; (d) 11% VNII NP-370 + + 4% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (e) 11% BFK + 4% SB-3 + 0.005% PMS-200A; (f) 4% BashNII-2 + + 4% PMS'Ya + 0.005% PMS-200A; (g) piston-ring mobility loss, points; (h) carbon scaling, points; (i) in first groove; (j) in other grooves; (k) in lands; (l) on piston skirt; (m) on inside piston surface; (n) in drainage holes and slots of oil-control rings; (o) over-all rating, points; (p) amount of scale in grooves and on rings, g; (q) sleeve wear, μ; (r) wear of set of rings, g.

agreement and reproducibility between parallel experiments either on a single bench unit or a number of such units.

4. Test results obtained for various foreign and Soviet oils on the UIM-6-NATI and UIM-6N-NATI machines agree with data obtained in long-term (500-800-hour) tests of the same oil samples in the D-50, SMD-14, D-28, SMD-18 and YaMZ-238NB tractor diesels.

5. Production and test samples of Soviet motor oils with additive compositions developed at the VNII NP, INKhP AN Azerb. SSR and BashNII NP were classified.

6. The quick test methods developed for Heavy Duty and Series 1 oils were standardized, and that devised for Series 2 is recommended for standardization and general use.

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OIL AND OIL-ADDITIVE SELECTION AND USE-PROPERTY MOTOR RATING FOR TWO-STROKE GASOLINE ENGINES

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As we know, the oil that lubricates two-stroke gasoline engines is introduced through the carburetor together with the fuel.

Depending on the design, physical condition, and operating conditions of the engines and on the properties of the oil and fuel used, the oil-to-fuel ratio varies from 1:15 to 1:40.

Oils for lubrication of two-stroke gasoline engines must meet the following main requirements:

they must burn with formation of the smallest possible amount of deposits, while ensuring minimal wear of engine rubbing parts under all engine operating conditions;

they may not contain particles capable of plugging the engine fuel-supply system;

they must ensure normal lubrication of the engine at minimum fuel consumption;

they must protect the parts of the engine and its fuel-supply system from corrosion;

stability of use properties during storage is required when they are mixed with additives and gasoline;

in the event that the gasoline becomes watered, the oil and additives may not settle out of the mixture.

Oils with varying viscosities, chemical compositions, and additive contents are used in various countries to lubricate two-stroke gasoline engines.

It has been established that light type A-6 oils with medium viscosity indices produce the smallest amounts of deposits on the piston, in the combustion chamber, in the scavenging and exhaust ports, and on spark-plug electrodes, while a heavier oil of type MS-20 with a high viscosity index eliminates seizing and scoring of the pistons.

Use of mixed light and heavy oils that have been matched with consideration of chemical composition, the specific use conditions, and the engine design gives good results.

The use properties of the oils are improved considerably by introduction of special additives. Use of commercial and tractor oils with ashing additives is not recommended, since the additives increase wear and the amount of deposits in the scavenging and exhaust ports, in the combustion chamber, and on the plug electrodes.

It should be noted that factory recommendations on oils to be used in two-stroke gasoline engines are frequently given without adequate technical justification.

At the All-Union Scientific Research Institute of Oil and Gas Processing and Production of Artificial Liquid Fuel (VNII NP), development of special additive oils was begun with elaboration of a spot-testing method using the SD-60B engine. Here it was necessary that:

the test method require little time and no more than 0.5 kg of the experimental oil, and that it provide reproducible experimental results corresponding to the results of long-term bench and use tests of oils in two-stroke gasoline engines of various designs;

the engine permit heat-load simulation of existing and projected two-stroke gasoline engines and provide sharp differentiation of oils on the basis of the main use indicators; further, that the engine be simple to operate and that it perform smoothly and reliably under various thermal loads, with adequate service life given replacement of the basic components – the piston and cylinder.

Among the two-stroke gasoline engines that we have at the present time, the SD-60B[1] meets these specifications, and was used as a basis for development of the bench installation and the oil spot testing method.

[1] See page 85 for footnote.

Unlike motor-vehicle and traction engines, it does not require an outside blower when operated under bench conditions. Its adequate cooling fan makes it possible to vary the thermal stressing of the engine over a broad range by throttling the air flow and, if necessary, to simulate use conditions.

Below we give the technical data of the SD-60B engine.

Available power, hp*...............	1.2
Crankshaft speed, rev/min..........	4000
Cooling............................	air
Fuel...............................	A-66 or B-70 gasoline mixed with oil (25:1)
Fuel consumption, g/hp-h, not above.......................	550
Weight of engine (without muffler), kg.....................	7
Guaranteed service life, h.........	600

*After climatic, altitude and amortization losses.

In designing the oil-testing installation, certain auxiliary equipment was provided to allow for changes in application of the engine; they make it possible to control and monitor its operating conditions.

Essentially, the method consisted in a short test of the oil in the engine at high temperature. The motor qualities of the oils were rated on the basis of the amount of deposits on a piston, in the cylinder head, and in the cylinder exhaust port, and from the degree of piston-ring mobility.

The use properties of the oil were determined by comparing the results of tests run on the same installation with the test oil and a control oil, in terms of the rating indicators adopted.

The control oils were base oils made according to the appropriate GOST [All-Union State Standards] and additive oils for two-stroke gasoline engines, which were prepared in accordance with the appropriate Technical Specifications [TU] (ТУ) or GOST's.

The control oil was tested after every 4-5 tests run with experimental samples. This made it possible to check the technical condition of the bench, its capability for differentiation, and the identity of the experimental conditions.

The following test conditions were adopted as a result of the studies (320 g of oil are required for 1 experiment):

Test time, h	10
Crankshaft speed, rev/min	4000±10
Compression ratio	
geometrical	7.1
actual	5.23

Spark timing before top dead center,
deg............................ 27-28
Fuel............................ B-70 gasoline, GOST 1012-54
Fuel consumption, kg/h............. 0.65
Composition of mixture (oil to fuel ratio)..................... 1:25
Temperatures, °C
ambient and intake-air.......... 40±2
crankcase....................... 100±2
cylinder head................... 220±2
cylinder, on generator side..... 170±2
cylinder, on starter side....... 195±5
exhaust gases................... 350±5
Exhaust back pressure, mm of water. 70±10

The oils were rated on the basis of a number of indicators that characterize their use properties (Table 1).

Table 1. Results of Tests of Additives with AS-9.5 Oil by IM2TD-10FG Method

a Присадка	b Содержание присадки, %	c Индекс отложений, баллы	d Подвижность поршневых колец	e Цвет отложений на поршне, баллы	f Количество отложений, г: g на поршне	h на днище поршня	i на головке цилиндра	j в выпускном окне	k суммарное
l АС-9.5 (базовое)	0	11	m Второе пригорело на 120°	5	0.36	0.09	0.16	0.11	0.72
n АСК	1.5	10.3	o Все свободны	1	0.23	0.13	0.29	0.33	0.98
p ЗЭЖК	1.5	8.2	Второе пригорело на 120°	5	0.28	0.03	0.07	0.06	0.44
q СЖК ($C_{10}-C_{16}$)	1.5	5.8	r То же	6	0.3	0.03	0.07	0.03	[illegible]
q СЖК ($C_{10}-C_{16}$)	1	5.7	Второе пригорело на 20°	5	0.15	0.02	0.03	0.04	0.25
АСК 1.5; СЖК ($C_{10}-C_{16}$) 1	1.5; 1	5.2	Все свободны	1	0.10	0.1	0.12	0.15	0.47
АСК; СЖК ($C_{10}-C_{16}$); s ТКФ; t ПМС-200А	1.5; 1; 0.2; 0.001	3.75	r То же	0.5	0.09	0.07	0.12	0.07	0.35

KEY: (a) additive; (b) additive content, %; (c) deposits index, points; (d) piston-ring mobility; (e) color of deposits on piston, points; (f) amount of deposits, g; (g) on piston; (h) on piston head; (i) on cylinder head; (j) in exhaust port; (k) total; (l) AS-9.5 (base); (m) second ring burned on 120°; (n) ASK; (o) all free; (p) EEZhK [ZhK = fatty acids]; (q) SZhK [synthetic fatty acids]; (r) same; (s) TKF [tricresyl phosphate]; (t) PMS-200A.

One of the indicators — the deposits index — is a conventional dimensionless over-all indicator of oil quality arrived at arbitrarily on the following basis:

Total amount of deposits on piston with rings, on piston head, in cylinder head and in exhaust port, arbitrary units....................... 10 (1 g)
Varnish on piston, arbitrary units...... 1 (2 points)
Piston-ring mobility, arbitrary units:
free.................................. 0
tight................................. 0.25
burned:
on 360°............................. 4
on 180°............................. 2

Table 2. Results of IM2TD-10FG-Method Tests of Oil Specimens with Domestic and Foreign Additives

a Продукты	b Состав горючей смеси	c Индекс отложений, баллы	d Подвижность поршневых колец	e Цвет отложений на поршне, баллы	f Количество отложений, г: g на поршне	h на днище поршня	i на головке цилиндра	j в выпускном окне	k суммарное
l АС 9,5 без присадки	1:25	13.4	m Первое пригорело на 360°, второе плотное	5	0.18	0.1	0.16	0.21	0.67
n АС-9,5+3% ВНИИ НП-370+1% ПМС'Я+0,5% ЛЗ-23к	1:25	8.7	o Все кольца свободны	1	0.07	0.23	0.28	0.2	0.82
p АС-9,5+3,5% ВНИИ НП-360+1% АзНИИ-ЦИАТИМ-1	1:25	6.8	Первое пригорело на 180°, второе q свободно	3.5	0.12	0.2	0.16	0.2	0.68
r АС-9,5+3% присадки ГДР для двухтактных бензиновых двигателей	1:25	10.9	o Все кольца свободны	4	0.25	0.13	0.24	0.1	0.82
s АС-9,5+2,5% присадки Амоко-661 (США)	1:25	8.4	t То же	0.5	0.15	0.13	0.21	0.3	0.82
u АС-9,5+3% присадки Эко-абб-120 (США)	1:25	3.8	•	0.5	0.08	0.2	0.25	0.3	0.56
v АС-9,5+1,5% АСК+1% СЖК ($C_{10}-C_{16}$)+0,001% ПМС-200А	1:25	3.8	•	0.5	0.08	0.01	0.13	0.01	0.36
w АС-9,5+1,5% АСК+1,5% ЗЭЖК+0,5% ТЭА (двухзамещенный)+0,001% ПМС-200А	1:25	4	•	0.5	0.09	0.01	0.12	0.06	0.38
x АС-9,5+17,5% Т-1+1,5% АСК+1% СЖК ($C_{10}-C_{16}$)+0,25% ВНИИ НП-354+0,001% ПМС-200А	1:33	3.2	•	0.5	0.05	0.0[illegible]	0.15	0.03	0.3
y АС-9,5+17,5% Т-1+1,5% АСК+1,5% ЗЭЖК+0,25% ВНИИ НП-354+0,001% ПМС-200А	1:33	3.8	•	0.5	0.07	0.0[illegible]	0.16	0.01	0.35

KEY: (a) products; (b) composition of fuel mixture; (c) deposits index, points; (d) piston-ring mobility; (e) color of deposits on piston, points; (f) amount of deposits, g; (g) on piston; (h) on piston head; (i) on cylinder head; (j) in exhaust port; (k) total; (l) AS-9.5 without additive; (m) first ring burned on 360°, second tight; (n) AS-9.5 + 3% VNII NP-370 + 1% PMS'Ya + 0.5% LZ-23k; (o) all rings free; [key cont'd on page 81]

[Key to Table 2, cont'd.](p) AS-9.5 + 3.5% VNII NP-360 + + 1% AzNII-TsIATIM-1; (q) first ring burned on 180°, second ring free; (r) AS-9.5 + 3% GDR [East Germany] additive for two-stroke gasoline engines; (s) AS-9.5 + + 2% Amoco 661 additive (USA); (t) same; (u) AS-9.5 + + 3% Ecolube 120 additive (USA); (v) AS-9.5 + 1.5% ASK + + 1% SZhK ($C_{10}-C_{16}$) + 0.001% PMS-200A; (w) AS-9.5 + 1.5% ASK + 1.5% EEZhK + 0.5% TEA (disubstituted) + 0.001% PMS-200A; (x) AS-9.5 + 17.5% T-1 + 1.5% ASK + 1% SZhK ($C_{10}-C_{16}$) + 0.25% VNII NP-354 + 0.001% PMS-200A; (y) AS-9.5 + 17.5% T-1 + 1.5% ASK + 1.5% EEZhK + 0.25% VNII NP-354 + 0.001% PMS-200A.

Each specimen was tested at least twice; here the disagreement between the results should not exceed ±10% for the wear and total-deposits indices, or ±0.5 point for the deposit color. The amount of scale is determined to within 0.001 g.

The work of selecting oil additives was begun with study of the functional properties of the individual additives on the bench engine.

It was established that the smallest amount of deposits in the combustion chamber and exhaust ports results from use of the low-ash alkylsalicylate additive ASK, 1.5% by weight of which eliminates piston-ring burning, reduces piston varnishing from 5 to 1 point, and simultaneously increases the amount of deposits on the piston head, in the cylinder head, and in the exhaust port (see Table 1).

Fatty acid ethyl ester (EEZhK) and synthetic fatty acids (SZhK) reduce the amount of deposits substantially but do not eliminate burning-on of the piston rings and do not reduce varnishing of the piston. More than 1% of SZhK in the oil causes deterioration of all motor-property indicators. Combined with ASK and SZhK, PMS-200A additive improves all indicators.

The studies established that each of the additives tested does not, taken alone, improve the properties of the base oil in all of the rating indicators. Subsequent development work on oils for two-stroke gasoline engines was directed toward adjustment of the additive combination.

Table 2 presents test results for mixes developed on the basis of ASK additive in combination with EEZhK, SZhK, and PMS-200A, for comparison with AS-9.5 base oil and with foreign additives. Mixes based on ASK are more effective. Additive mixes containing synthetic fatty acids ($C_{10}-C_{16}$ fraction), which were used for 850-1000 hours in Druzhba-4 gasoline-powered saws, produced somewhat better results than mixes of the same additives containing EEZhK. When AS-9.5 oil was used with an additive mix consisting of 1.5% ASK, 1% SZhK, and 0.001% PMS-200A, the service life of the Druzhba-4 engine was increased by a factor of 2. This oil is recommended by the interdepartmental commission for experimental use. The good use properties of AS-10 oil with

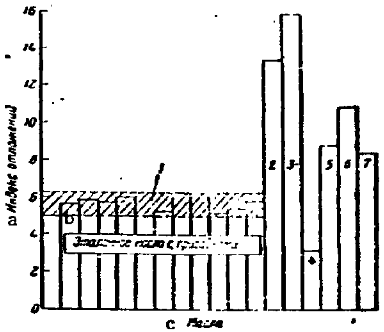

Fig. 1. Reproducibility of test results and comparison of various oils on the basis of the "deposits index" indicator. 1) scattering region of control-oil test results; 2) AS-9.5 (without additive); 3) AK-15 (without additive); (4) VNII NP mix; 5) AS-9.5 + 3% Ecolube 120; 6) AS-9.5 + + 3% GDR additive; 7) AS-9.5 + 2.5% Amoco 661.
KEY: (a) deposits index; (b) control oil with additives; (c) oil.

17.5% of T-1 fuel, 1.5% ASK, 1% SZhK, 0.25% VNII NP-354, and 0.001% PMS-200A and a similar mix with 1.5% EEZhK were confirmed by the results of use tests extending over the entire lifetime of SD-60B engines. In tests of engine performance on AS-9.5 oil without additives (mixture composition 1:25), it was necessary to replace the piston pin and the connecting-rod top-end insert after 460 hours because of wear. Engines ran for more than 700 hours on AS-9.5 oil with the additive composition developed (mixture composition 1:33) without replacement of parts or removal of deposits.

The method developed makes it possible to obtain a reproducibility of the results that is adequate for motor tests, along with sharp enough differentiation between different oil qualities (Fig. 1).

The installation developed performs reliably over a broad cylinder-temperature range. Oils can be rated in research studies at cylinder temperatures from 170 to 230°C. The maximum cylinder temperature for tests of various oils and additives is limited by the onset of ring burning and piston scoring. For effective special-additive mixes, it ranges up to and above

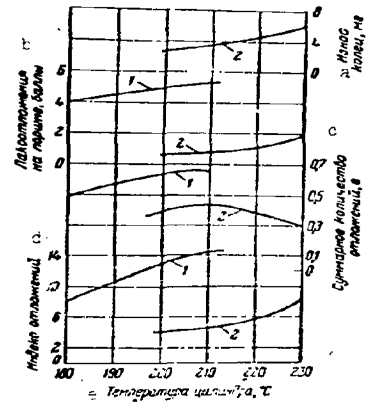

Fig. 2. Influence of thermal load of IM-TD-10FG bench engine on test results for various oils. 1) DS-11 oil (without additive); 2) DS-11 oil with 1.5% ASK, 1% CZhK, and 0.001% PMS-200A.
KEY: (a) ring wear, mg; (b) piston varnishing, points; (c) total amount of deposits, g; (d) deposits index; (e) cylinder temperature, °C.

...°C; for oils not having additives, it is usually 180-200°C. The results of ten-hour tests at various cylinder temperatures make it possible to plot characteristic curves for oils with cylinder temperature and the rating indicator as coordinates (Fig. 2). Comparison of these characteristics for various oils forms a basis for predicting their range of application.

In ten-hour sequential tests of the oil, its antiwear properties can be rated quite reliably within 40-50 hours. When DS-11 oil was used without additives in 40 hours of operation with cylinder temperatures between 180 and 210°C, the total piston-ring wear was 0.027 g, but only 0.017 g with 1.5% ASK, 1% CZhK (C_{10}-C_{16}), and 0.001% PMS-200A over the same running time at cylinder temperatures of 200-230°C.

A full-scale bench installation has now been built around the ...-60B engine and can be used to test oils for two-stroke gasoline engines.

CONCLUSIONS

1. A method was developed for motor rating of the use properties of oils made for two-stroke gasoline engines.

2. The method can be used to rate oils with and without additives, to determine the functional properties of specific additives, and to adjust optimum additive mixes.

3. The method yields satisfactory reproducibility in the test results. The divergence of two parallel tests is ± 10% for the deposits index and the total amount of deposits.

4. The bench installation and the method elaborated for it have enabled the VNII NP to develop special two-stroke gasoline-engine oils whose operational properties are considerably better than those of the commercial oils currently being produced.

5. The motor-rating method can be recommended for State Standards and Departmental Technical Specifications; it can be used in scientific-research organizations, at petroleum refineries, and by consumers to check oil quality.

Footnote

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77	[1] A stationary single-cylinder two-stroke engine with two-channel return-counterflow scavenging.

IN-STORAGE PROPERTY CHANGES OF OILS OF VARIOUS CLASSES AND DETERMINATION OF THEIR PURITY

K.K. Papok and B.S. Zuseva

CHANGE IN THERMAL-OXIDATION STABILITY AND DETERGENT POTENTIAL OF ADDITIVE OILS DURING STORAGE

With the object of determining how the thermal-oxidation stabilities and detergent potentials of additive oils change during storage, oils of various classes (from Premium to Series 3) were prepared with DS-11 oil as a base and with various combinations of foreign and domestic additives and placed in long-term storage.

A consignment of oils with foreign additives was prepared under laboratory conditions in August 1961. Each specimen had a volume of 0.5 liter. The oil samples were stored in glass bottles in diffuse light in a closed unheated warehouse. Control analyses were made in February 1964 and April 1965.

The analyses (Table 1) showed that after 2 years and 7 months of storage, all oils with mixes of foreign barium and calcium additives retained thermal-oxidation stability (except for the calcium-additive Series 3 oil), while after 3 years and 9 months of storage, thermal-oxidation stability had declined by 10–25 minutes in 50% of the specimens, namely, in oils of the Heavy Duty, Series 1 and Series 3 classes with barium additives and in Premium, Series 1 and Series 3 oils with the calcium additives.

Table 1. Change in Properties of Various Classes of Oils During Storage in Glass Bottles

a Масла	b Содержание присадок в масле ДС-11	c Термоокислительная стабильность, мин: d у исходного образца	e после 2 лет и 7 месяцев хранения	f после 3 лет и 9 месяцев хранения	g Моющий потенциал, %: d у исходного образца	e после 2 лет и 7 месяцев хранения	f после 3 лет и 9 месяцев хранения
h Премиум	i 0,7% антиокислительной +0,7% бариевой	52	49	55	10	5	10
j Хеви-Дьюти	0,7% антиокислительной +1,5% бариевой	60	56	50	20	20	20
k Серия 1	0,25% антиокислительной + 4% бариевой	60	58	34	50	50	60
k Серия 2	0,7% антиокислительной +9% бариевой	86	84	—	75	80	—
k Серия 3	18% бариевой	76	73	63	85	85	90
n Премиум	0,6% антиокислительной	45	49	35	30	5	5
j Хеви-Дьюти	0,6% антиокислительной +2,6% кальциевой	45	40	45	60	30	35
k Серия 1	0,5% антиокислительной +4,5% кальциевой	45	40	35	65	—	60
k Серия 2	11% кальциевой o	47	46	45	85	—	90
k Серия 3	17% кальциевой o	68	52	54	85	—	90
p Для судовых двигателей	25% кальциевой o	110	92	139	85	—	90

KEY: (a) oil; (b) content of additives in DS-11 oil; (c) thermal-oxidation stability, minutes; (d) original specimen; (e) after 2 years 7 months of storage; (f) after 3 years 9 months of storage; (g) detergent potential, %; (h) Premium; (i) 0.7% antioxidant + 0.7% barium; (j) Heavy Duty; (k) Series...; (l) 18% barium; (m) 0.6% antioxidant; (n) 0.6% antioxidant + 2.6% calcium; (o) ...% calcium; (p) for marine engines.

Detergent potential remained unchanged in all oils after three years and nine months of storage, except for the Premium and Heavy Duty oils with calcium additives, which showed a sharp drop in detergent potential even after 2 years and 7 months.

In August 1962, a consignment of oils with various additives, prepared under semiindustrial conditions and packaged in steel drums, was obtained from the VNII NP. 0.5-liter samples of the oils were drawn from these drums into glass bottles and placed in a closed unheated warehouse for storage. The drums were then stored on an outdoor platform.

Control analyses, the results of which appear in Table 2, were made in February 1964 and April 1965.

As we see, even after 1.5 years of storage, whether in the glass bottles or in the steel drums, the thermal-oxidation stabilities of all the oils except the Series 1 and Series 2 oils with calcium additives had dropped by 12-30 min, and after 2

Table 2. Change in Properties of Oils of Various Classes During Storage*

a Масла	b Условия хранения	c Термоокислительная стабильность, мин: d у исходного образца	e после 1,5 года хранения	f после 2 лет и 8 месяцев хранения	g Моющий потенциал, %: d у исходного образца	e после 1,5 года хранения	f после 2 лет и 8 месяцев хранения
h С бариевыми присадками:							
i Премиум	В стеклянной таре j	55	42	38	20	10	10
	В железных бочках k	55	40	—	20	0	—
l Хеви-Дьюти	В стеклянной таре j	62	46	40	30	40	30
	В железных бочках k	62	47	—	30	40	—
m Серия 2	В стеклянной таре j	75	50	40	85	85	80
	В железных бочках k	75	50	—	85	85	—
m Серия 3	В стеклянной таре j	70	41	35	90	85	85
	В железных бочках k	70	40	—	90	85	—
n С кальциевыми присадками:							
l Хеви-Дьюти	В стеклянной таре j	45	32	29	50	50	30
	В железных бочках k	45	32	—	50	50	—
m Серия 1	В стеклянной таре j	37	44	36	60	50	20
	В железных бочках k	37	39	—	60	60	—
m Серия 2	В стеклянной таре j	40	42	40	90	90	30
	В железных бочках k	40	38	—	90	80	—
m Серия 3	В стеклянной таре j	75	64	35	90	90	30
	В железных бочках k	75	62	—	90	85	—

*The additive contents of the various oils are the same as in Table 1.
KEY: (a) oil; (b) storage conditions; (c) thermal-oxidation stability, minutes; (d) original specimen; (e) after 1.5 years of storage; (f) after 2 years 8 months of storage; (g) detergent potential, %; (h) with barium additives; (i) Premium; (j) in glass bottles; (k) in steel drums; (l) Heavy Duty; (m) Series...; (n) with calcium additives.

years and 8 months of storage, a further decrease in thermal-oxidation stability was noted in the oils stored in glass (no further observations were made on the oil in the drums after 1.5 years).

Except for Premium oil with barium additives, the detergent potentials of all oils had undergone no change after 1.5 years of storage, while after 2 years and 8 months, all oils with calcium additives showed a 20-60-unit loss of detergent potential.

It is interesting to note that the oils prepared in the laboratory (August 1961) were more stable during storage in glass than oils prepared under semiindustrial conditions (see Tables 1 and 2). This provides a basis for the assumption that the conditions of mixing of the oils with the additives influence storage stability.

The results of analyses of the oils with Soviet additives appear in Table 3.

Table 3. In-Storage Property Changes of Oils of Various Classes with Soviet Additives

a Масла	b Содержание присадок в масле ДС-11	c Условия хранения	d Термоокислительная стабильность, мин: e у исходного образца	f после 1,5 лет хранения	g после 2 лет и 8 месяцев хранения	h Моющий потенциал, %: e у исходного образца	f после 1,5 лет хранения	g после 2 лет и 8 месяцев хранения
i Хейви-Дьюти	j 3% ВНИИ НП-370+1% ПМС'Я+0,5% ЛЗ-23к+0,005% ПМС-200А	k В стеклянной таре	65	62	45	50	80	40
		l В железных бочках	65	65	—	50	80	—
m Серия 1	n 5% ВНИИ НП-370+2% ПМС'Я+0,5% ЛЗ-23к+0,005% ПМС-200А	k В стеклянной таре	68	68	53	55	55	60
		l В железных бочках	68	53	—	55	60	—
m Серия 2	o 11% ВНИИ НП-370+4% ПМС'Я+0,5% ЛЗ-23к+0,005% ПМС-200А	k В стеклянной таре	77	62	63	90*	50*	0
		l В железных бочках	75	75	—	90*	70*	—
m Серия 3	p 15% ВНИИ НП-370+6% ПМС'Я+0,5% ЛЗ-23к+0,005% ПМС-200А	k В стеклянной таре	89	82	80	95*	40*	0
		l В железных бочках	89	80	—	95*	—	—

*Filtered specimens.

KEY: (a) oil; (b) additive content in DS-11 oil; (c) storage conditions; (d) thermal-oxidation stability, minutes; (e) original specimen; (f) after 1.5 years of storage; (g) after 2 years 8 months of storage; (h) detergent potential, %; (i) Heavy Duty; (j) 3% VNII NP-370 + 1% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (k) in glass bottles; (l) in steel drums; (m) Series 1; (n) 5% VNII NP-370 + 2% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (o) 11% VNII NP-370 + 4% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (p) 15% VNII NP-370 + 6% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A.

After 1.5 years of storage, the thermal-oxidation stabilities of all oils (except for two specimens) remained practically unchanged, but after 2 years and 8 months of storage in glass, they fell by 8-20 min. The detergent potentials of the Heavy Duty and Series 1 oils had not changed after 2 years and 8 months of storage; for the Series 2 and Series 3 oils, they had fallen by 20-55 units after 1.5 years of storage, and to zero after 2 years and 8 months.

INVESTIGATION OF PURITY OF MOTOR OILS AND ADDITIVES

The following method was worked out for determination of the purity of the oils and additives. The oil or additive specimen to be studied was dissolved in Galosha gasoline at room temperature and passed under vacuum (residual pressure 20-30 mm Hg) through a No. 4 biological filter 27 mm in diameter, which was placed in a two-part metal funnel (GOST [All-Union State Standard] 10734-64). To determine the purity of the oils, 5-gram weighed specimens were taken and dissolved in 45 ml of Galosha gasoline; to determine additive purity, 1-gram weighed samples were dissolved in 49 ml of Galosha gasoline.

The purity of an oil or additive is determined from the filtration number and the amount of dirt in the oil. The filtration number is determined from the number of filters needed for complete filtering of the entire oil or additive solution with filter change mandatory at 5-minute intervals.

The amount of dirt is determined from the difference in the weights of the biological filter before and after filtration of the oil solution (bringing it to constant weight at 100°C). When it is necessary to change filters several times, as when the products being tested contain large amounts of contamination, the total amount of deposits on all of the filters is taken as the fouling index of the oil. The amount of dirt is expressed in mg/100g of the oil or additive being tested.

The disagreement between parallel experiments may not exceed 20 mg/100g for dirt contents up to 200 mg/100g, or 10% of the smallest result for dirt contents above 200 mg/100g. The fouling of the oil can also be rated tentatively by visual inspection on the basis of filter color.

It was found on checking the purity of the motor oils without additives that in general, all of the commercial oils show high purity: the number of filtrations was 1, i.e., they were thoroughly filtered by a single filter, and the amount of dirt did not exceed 30 mg/100g.

The purity of motor oils containing various additives fluctuates in a very broad range: as many as 6 filters were required to clear some specimens, and the amount of dirt ranged up to 300 mg/100g (Table 4).

Oils with the Monto, Santolube, and Orobis additives showed high purity: the filtration number was 1, and the amount of dirt ranged from 26 to 40 mg/100g. On the other hand, oils with the VNII NP-370, BFK-1, SB-3, and other additives were very dirty: they required up to 6 filtrations and contained up to 308 mg/100g of dirt.

The purity change of mineral oils under the influence of additives is accounted for by inadequate purity of the additives themselves (Table 5). We see from the table that the filtration

Table 4. Purities of Various Classes of Oil

a Масло	b Содержание присадок в масле ДС-11	c Степень чистоты: d число фильтраций	e загрязнение мг/100 г
f Премиум	g 0,7% Сантолюб-493 + 0,7% Монто-613	1	40
h	0,6% Оробис-267	1	28
i	5% СК-11 + 1,2% ДФ-11	2	168
j	5% СК-3 + 1,2% ДФ-11	1	96
k	0,7% ЛАНИ-317 + 0,7 % БФК-1	1	46
l Хеви-Дьюти	0,7% Сантолюб-493 + 1,5% Монто-613 g	1	36
m	0,6% Оробис-267 + 2,6% Оробис-2054	1	26
n	3% ВНИИ НП-370 + 1% ПМС'Я + 0,5% ЛЗ-23к + +0,005% ПМС-200А	2	236
o	5% БФК-1 + 2% СБ-3 + 0,005% ПМС-200А	2	106
p	0,7% ЛАНИ-317 + 1,5% БФК-1	1	72
q Серия 1 r	0,25% Сантолюб-493 + 4% Монто-613	1	36
s	0,5% Оробис-267 + 4,5% Оробис-2054	1	50
t	5% ВНИИ НП-370 + 2% ПМС'Я + 0,5% ЛЗ-23к + +0,005% ПМС-200А	2	116
u	5% БФК-1 + 3% СБ-3 + 0,5% ЛЗ-23к + 0,005% ПМС-200А	2	184
v	0,25 ЛАНИ-317 + 4% БФК-1	1	76
q Серия 2 w	0,7% Сантолюб-493 + 9% Монто-613	1	36
x	11% Оробис-2054	1	32
y	11% ВНИИ НП-370 + 4% ПМС'Я + 0,5% ЛЗ-23к + +0,005% ПМС-200А	6	308
z	11% БФК-1 + 4% СБ-3 + 0,5% ЛЗ-23к + 0,005% ПМС-200А	2	142
aa	0,5% ЛАНИ-317 + 6,5% БФК-1 + 0,005% ПМС-200А	2	64
q Серия 3	18% Монто-702 bb	1	30
cc	17% Оробис-2112А	1	34
dd	15% ВНИИ НП-370 + 6% ПМС'Я + 0,5% ЛЗ-23к + +0,005% ПМС-200А	5	258
ee	15% БФК-1 + 6% СБ-3 + 0,5% ЛЗ-23к + 0,005% ПМС-200А	1	136
ff	1% ЛАНИ-317 + 10% БФК-1 + 0,005% ПМС-200А	1	88

KEY: (a) oil; (b) additive content in DS-11 oil; (c) purity; (d) filtration number; (e) dirt, mg/100g; (f) Premium; (g) 0.7% Santolube 493 + 0.7% Monto 613; (h) 0.6% Orobis-267; (i) 5% SK-11 + 1.2% DF-11; (j) 5% SK-3 + 1.2% DF-11; (k) 0.7% LANI-317 + 0.7% BFK-1; (l) Heavy Duty; (m) 0.6% Orobis-267 + 2.6% Orobis-2054; (n) 3% VNII NP-370 + 1% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (o) 5% BFK-1 + 2% SB-3 + 0.005% PMS-200A; (p) 0.7% LANI-317 + 1.5% BFK-1; (q) Series...; (r) 0.25% Santolube 493 + 4% Monto 613; (s) 0.5% Orobis-267 + 4.5% Orobis 2054; (t) 5% VNII NP-370 + 2% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (u) 5% BFK-1 + 3% SB-3 + 0.5% LZ-23k + 0.005% PMS-200A; (v) 0.25% LANI-317 + 4% BFK-1; (w) 0.7% Santolube 493 + 9% Monto 613; (x) 11% Orobis 2054; (y) 11% VNII NP-370 + 4% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (z) 11% BFK-1 + 4% SB-3 + 0.5% LZ-23k + 0.005% PMS-200A; (aa) 0.5% LANI-317 + 6.5% BFK-1 + 0.005% PMS-200A; (bb) 18% Monto-702; (cc) 17% Orobis-2112A; (dd) 15% VNII NP-370 + 6% PMS'Ya + 0.5% LZ-23k + 0.005% PMS-200A; (ee) 15% BFK-1 + 6% SB-3 + 0.5% LZ-23k + 0.005% PMS-200A; (ff) 1% LANI-317 + 10% BFK-1 + 0.005% PMS-200A.

number was 1 for the LANI-317, Santolube-493, Monto-613 and 702 and Orobis-267, 2054, and 2112A additives, while they contained no more than 80 mg/100g of dirt.

Table 5. Purities of Various Additives

a Присадки	b Степень чистоты: c число фильтраций	d загрязнение мг/100 г
e Сантолюб-493	1	75
f Монто-613	1	75
g Оробис-2054, 267, 2112А	1	80
h Монто-702	1	50
i ЛАНИ-317	1	80
j ЦИАТИМ-339	1	140
k БФК-1	1	190
l ЛЗ-23к	1	210
m ВНИИ НП-371	1	220
n ВНИИ НП-360	1	300
o АзНИИ-ЦИАТИМ-1	2	600
p АзНИИ-7	2	850
q ИП-22	4	520
r ВНИИ НП-370	4	850
s ВНИИ НП-167	4	1260
t СБ-3	4	1350
u ПМС'Я	9	2070

KEY: (a) additive; (b) purity; (c) number of filtrations; (d) dirt, mg/100g; (e) Santolube-493; (f) Monto-613; (g) Orobis-2054, 267, 2112A; (h) Monto-702; (i) LANI-317; (j) TsIATIM-339; (k) BFK-1; (l) LZ-23k; (m) VNII NP-371; (n) VNII NP-360; (o) AzNII-TsIATIM-1; (p) AzNII-7; (q) IL-22; (r) VNII NP-370; (s) VNII NP-167; (t) SB-3; (u) PMS'Ya.

However, most of the additives have indicators inferior to those named above, and additives such as PMS'Ya, SB-3, and VNII NP-370 were very dirty (from 850 to 2070 mg/100g) and had filtration numbers from 4 to 9. However, any of the additives may be prepared in different purities.

The purities of laboratory-mixed (August 1961) and semi-industrial (April 1964) oils with foreign additives and domestic semiindustrially-mixed oils were checked. As we see from Table 6, the semiindustrially mixed oils are considerably dirtier than the lab-mixed oils, and this is apparently the explanation for the stability differences during storage.

It is recommended that the purity-rating method be used to monitor the purity of oils and additives, using the norms given in Table 7 as a guide.

Table 6. Purities of Oils of Various Classes Mixed in the Laboratory and Under Semiindustrial Conditions

a Масло	b Степень чистоты: c число фильтраций, d лабораторное смешение	c число фильтраций, e полузаводское смешение	f загрязнение, мг/100 г, d лабораторное смешение	f загрязнение, мг/100 г, e полузаводское смешение
g С зарубежными бариевыми присадками				
h Премиум	1	1	28	46
i Хеви-Дьюти	1	2	48	104
j Серия 2	1	3	38	196
j Серия 3	1	2	30	86
l С зарубежными кальциевыми присадками				
h Премиум	1	—	54	—
i Хеви-Дьюти	1	2	30	56
j Серия 2	1	2	32	152
m С отечественными присадками ВНИИ НП				
j Серия 1	—	4	—	72
j Серия 2	—	6	—	308
j Серия 3	—	5	—	258

KEY: (a) oil; (b) purity; (c) number of filtrations; (d) laboratory mixing; (e) semiindustrial mixing; (f) dirt, mg/100g; (g) with imported barium additives; (h) Premium; (i) Heavy Duty; (j) Series ...; (l) with imported calcium additives; (m) with domestic VNII NP additives.

Table 7. Acceptable Purity Standards

a Продукты	b Степень чистоты: c число фильтраций	d загрязнение, мг/100 г (не более)
e Масла без присадок	1	30
f Масла с присадками	1	50
g Присадки	1	150

KEY: (a) product; (b) purity; (c) number of filtrations; (d) dirt, mg/100g (not above); (e) oil without additives; (f) oil with additives; (g) additives.

CONCLUSIONS

1. During prolonged storage, thermal-oxidation stability and detergent potential decline in oils of various classes (from Premium to Series 3, inclusive) with both foreign and domestic additives.

2. Oils with calcium additives are less stable than oils with barium additives as regards changes in detergent potential during storage.

3. In oils of unsatisfactory purity, thermal-oxidation stability and detergent potential change at a considerably earlier date during storage than in the cleaner oils.

4. A laboratory method was worked out for rating oil and additive purity, and purity norms were recommended for oils with and without additives and for the additives themselves.

USE OF PAIRED ANTIOXIDANTS FOR TURBINE OILS

K.I. Ivanov, Ye.D. Vilyanskaya, A.A. Luzhetskiy
and A.N. Aleksandrov

There is as yet no generally accepted theory that explains the phenomenon of synergism observed when mixtures of hydrocarbon-oxidation inhibitors (antioxidants, retarders) are used, i.e., the mutual enhancement of their action that is observed in many cases.

At the present time, there are two main views as to the nature of the synergism. According to one of them (in the case of a mixture of an aromatic amine with phenols), one molecule of the amine in the presence of [illegible] alcoholic or other hydroxyl-containing compounds deactivates [illegible] one or two of the peroxide radicals, as is usually the case, but a much larger number. This is possible only as a result of radical interaction between the inhibitors, for example, according to the scheme

$$AmH + RO_2\cdot \rightarrow Am\cdot + ROOH$$
$$Am\cdot + HO\Phi \rightarrow AmH + \Phi O\cdot$$

when the original amine is regenerated [1], or as a result of formation of condensation products between the amine and the phenol (or hydroxyl-containing reaction products) with a hydrogen bond at the nitrogen: $R-\underset{H}{\overset{H}{N}}\ldots HO\Phi$, which are active inhibitors that terminate chains without consumption (in the net result) of the NH_2 group, but with participation of the phenol OH group [2].

According to the second view of the synergistic effect, inhibitors are classified into three kinetic groups that differ in chemical structure and are capable of deactivating various intermediate products on which initiation and development of the chain oxydation reaction depend [3-5]. It has been established by research at the All-Union Institute of Heat Engineering (BTИ) that group I retarders interact only with free hydrocarbon radicals $R\cdot$, and not with hydroperoxides ROOH or free peroxide radicals $RO_2\cdot$; group II retarders react vigorously with hydroperoxides and with $RO_2\cdot$, and do not react with hydrocarbon radicals $R\cdot$; group III retarders react with $R\cdot$ and $RO_2\cdot$ and interact either sluggishly or not at all with hydroperoxides [5].

In this context, we may assume that in the simultaneous presence of antioxidants of various groups (I and II, II and III, I and III), their effects tend to strengthen one another (synergistic effect), with the result that inhibition of the oxidation process is maximized.

For example, we might assume that in the combined presence of group I and II retarders, the group I antioxidant deactivates most of the $R\cdot$ radicals formed during the initiation phase, while those that still exist and have time to convert to $RO_2\cdot$ are handled by the group II antioxidant.

Inhibitors of groups II and (to a certain degree) III may, moreover, produce a synergistic effect by interacting with accumulating hydroperoxides, thus preventing branching of the reaction chain.

The first hypothesis is consistent with the fact that amine inhibitors are capable in many cases of forming complexes with hydroxyl-containing compounds; here, a hydrogen bond forms to the nitrogen, as has been demonstrated on the example of primary aromatic amines and cumene hydroperoxides. These complexes also have inhibiting properties. However, this theory does not take account of the fact that the action of oxidation inhibitors consists in capturing not only peroxide radicals $RO_2\cdot$, but also other active particles (hydrocarbon radicals $R\cdot$, alkoxy radicals $RO\cdot$). Nor does this theory consider the experimentally established differences between the abilities of different inhibitors, depending on their structure, to react with different intermediate products of the oxidation process.

The second theory takes these factors into account. It permits purposive selection of a broad range of inhibitor mixtures that produce the synergistic effect. The possibility of such selection has been confirmed experimentally under laboratory and industrial conditions.

Laboratory and use tests have shown that given proper selection, the stabilizing action of two additives on turbine oils exceeds that of either of them taken alone at twice the concentration. This proves that we are dealing not with simple addition of the effects of two antioxidants, but with mutual enhancement of their activities. It has also been proven that a mixture of antioxidants of the same kinetic group does not, as a rule, produce the synergistic effect [6].

Effectiveness of Paired Antioxidants
Under Laboratory Conditions

a Продукт	b Общая стабильность по ГОСТ 981—55	
	c Кислотное число, мг КОН/г	d Содержание осадка, %
e Масло турбинное I	0,61	0,160
f То же +0,02% компонента А	0,18	0,010
g » +0,1% компонента Б	0,17	0,023
f » +0,01% компонента А g +0,05% компонента Б	0,05	h Следы
i Масло турбинное II	0,46	0,06
f То же +0,01% компонента А	0,14	0
g » +0,05% компонента Б	0,25	0,04
f » +0,01% компонента А+ g +0,05% компонента Б	0,07	0,01

KEY: (a) product; (b) over-all stability according to GOST 981-55; (c) acid number, mg of KOH/g; (d) sediment content, %; (e) turbine oil I; (f) same + ...% of component A; (g) same + ...% of component B; (h) traces; (i) turbine oil II.

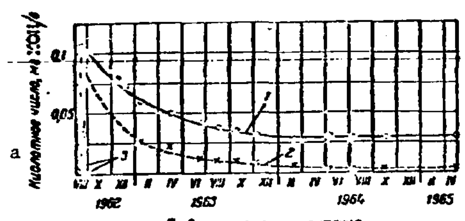

Fig. 1. Change in acid number of oil after introduction of paired antioxidant. 1) total acid number; 2) acid number due to water-soluble acids; 3) introduction of paired antioxidant.
KEY: (a) acid number, mg of KOH/g; (b) test time.

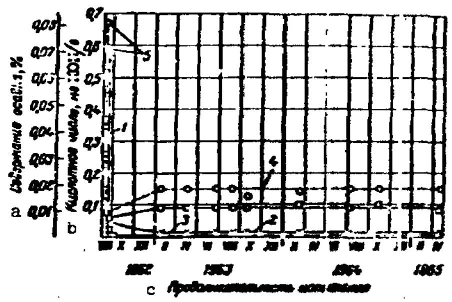

Fig. 2. Change in stability of oil after introduction of paired antioxidant. 1) acid number; 2) content of nonvolatile acids; 3) content of volatile acids; 4) sediment content; 5) introduction of paired antioxidant.
KEY: (a) sediment content, %; (b) acid number, mg of KOH/g; (c) test time.

Of special practical interest for inhibiting oxidative aging of lubricating and insulating oils as a result of possible synergistic effects is the use of mixtures of antioxidant additives in which, in addition to the true inhibitors (i.e., substances that terminate reaction chains), there are retarders with other mechanisms of action — primarily deactivators and passivators for metals (chiefly copper and iron) that come into contact with turbine and transformer oils under use conditions and catalytically accelerate their aging.

It must be remembered in testing various antioxidant pairs that they must dissolve well in oils and ensure stability without detriment to other use properties.

A paired antioxidant consisting of 0.1% β-naphth[illegible], which belongs to group III of the classification proposed earlier [illegible], and 0.03% phenyl-β-naphthylamine, a group I antioxidant, was tested after laboratory study in the oil system of a [illegible] turbogenerator. The oil with this antioxidant pair stood up for 1.5 years without the use of adsorbents. After 1.5 years [illegible], the acid number of the stabilized oil was considerably below those of unstabilized oils previously used in this turbine with adsorbents for the same period of time.

Tests were run on one more mixture, which consists of a group III antioxidant (component A) that has simultaneously [illegible] properties of a metal deactivator and a group I antioxidant (component B). The effectiveness of this mixture [illegible]

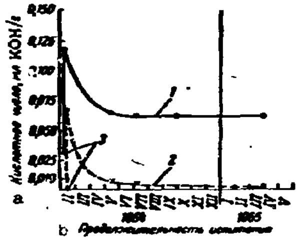

Fig. 3. Change in acid number of oil after introduction of paired antioxidant. 1) total acid number; 2) acid number due to water-soluble acids; 3) introduction of paired antioxidant. KEY: (a) acid number, mg of KOH/g; (b) test time.

under laboratory conditions according to GOST 981-55. The test results are given in the table. The table shows that the proposed antioxidant pair has a very sharp inhibiting effect on the aging of turbine oil. The acid number after aging was smaller by a factor of 12 than that of the pure oil and smaller by a factor of 3 than the acid number of the same oil with twice the concentration of one of the components. The amount of sediment is also smaller, in confirmation of the effectiveness of this paired antioxidant.

Use tests were then run with this antioxidant pair in a 24,[illegible]-kW turbogenerator.

Figure 1 shows the change in the acid number of the stabilized oil during operation of the turbogenerator. Figure 2 shows the change in its stability (after GOST 981-55) after introduction of the paired antioxidant.

It was established by the tests that after 3.5 years of use, the oil had an acid number of 0.03 mg of KOH/g, i.e., it was practically the same as the norm for fresh oil (0.02 mg of KOH/g). It should be noted that no additive was introduced into the fresh oil over the 3.5 years. It was established on inspection of the turbine (after 2 years of operation), that its oil system did not require cleaning. Operating experience from previous years shows that without the paired antioxidant, oil lasted 2 years in this turbine only with continuous adsorbent regeneration.

The adsorbent had to be changed repeatedly, with the resulting higher labor cost and a considerable increase in use of the expensive adsorbent.

The same paired antioxidant was tested in another turbine. Figure 3 shows the changes of the oil's indicators in this turbine. The tests are being continued successfully. The use tests show that the proposed paired antioxidant inhibits the turbine-oil aging process more actively than other antioxidant additives and does not require special checking by servicing personnel. At this writing, use tests are being run with the paired antioxidant in four turbogenerators.

CONCLUSIONS

1. Mixtures of antioxidants for turbine oils, adjusted on the basis of theoretical notions developed by the authors, give a pronounced synergistic effect when tested under laboratory conditions.

2. The results of the laboratory tests are confirmed by data from use testing of the paired antioxidant, in the presence of which the original properties of the oil are retained fully over a long operating interval.

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ADDITIVE MIXES FOR STABILIZATION OF TRANSFORMER OILS

M.I. Shakhnovich

Use of oil-stabilizing additives prolongs the useful lives of transformers, improves their reliability, and permits improvements to their design. Among the insulating and structural materials used in the transformer, copper is the most active catalyst of the oxidation of mineral insulating oils.

Under use conditions, copper structures come into contact with the oil, and dissolved copper is found in the oil itself in the form of salts of organic acids.

Used transformer oil contains up to 0.0001% of copper [1]. It has been shown [2] that the amounts of antioxidant additives consumed in inhibiting hydrocarbon oxidation in the presence of copper are considerably larger than under the same conditions without the catalyst. With the large amount of copper present when oil is oxidized in transformers, it is necessary to use very large amounts of antioxidants (0.3-0.5% by weight).

The stability of transformer oils can be increased much more effectively by using deactivating and passivating additives. Deactivators produce their effect by interacting chemically with salts of metals dissolved in the oil. This leads to formation of chelate complexes in which the metal is screened and cannot act as a catalyst. The complexes formed may settle out or remain dissolved in the oil.

Salicylidenes — Schiff bases obtained by condensing amines with aromatic aldehydes — are used as deactivators.

Basic Physicochemical Indicators of Transformer Oils

a Масло	b Очистка	c Плотность d_4^{20}	d Коэффициент преломления n_D^{20}	e Вязкость при 20 °C, сст	f tg δ при 70 °C, %	g Структурно групповой анализ: C_A, %	C_H, %	K_A	K_H
h Из смеси бакинских нефтей	i Кислотно-щелочная	0.8832	1.4875	27.2	1.1	11.3	42.7	0.34	1.72
j Из бузовнинской нефти	k Адсорбционная	0.8829	1.4893	28.9	0.4	14.2	38.3	0.45	1.55
l Из смеси эмбенских нефтей	m Кислотно-щелочная	0.8887	1.4897	22.1	2.5	13.3	45.1	0.48	1.70
n Из анастасиевской нефти	o То же	0.8967	1.4975	19.6	2.5	22.7	38.0	0.56	1.48
p Из туймазинской нефти	q Фенольная	0.8610	0.4730	25.7	0.3	5.1	34.6	0.14	1.85
o То же	Гидрирование и контактная доочистка	0.8876	1.4960	25.3	0.2	20.6	28.5	0.62	1.13
s Импортное (ГДР)		0.8936	1.4928	25.9	0.7	14.3	42.8	0.42	1.64

KEY: (a) oil; (b) refining; (c) density; (d) refractive index; (e) viscosity at 20°C, cst; (f) tan δ at 70°C, %; (g) structural-group analysis; (h) from mixed Baku crudes; (i) acid-base; (j) from Buzovninsk crudes; (k) adsorption; (l) from mixed Emba crudes; (m) acid-base; (n) from Anastas'yev crude; (o) same; (p) from Tuymazy crude; (q) phenol; (r) hydrogenation and contact refining; (s) imported (GDR).

Passivators act by a somewhat different mechanism; they with the copper, they form a catalytically inactive film on the surface. It is assumed that the passivator is chemisorbed in the process.

The passivating additives include certain amino acids. Quite often, the same compound acts as both a deactivator and a passivator [1].

Reference [3] describes experiments in which additives of this type were used separately and in combinations, but it would be interesting to study the manner in which these additives increase the stability of domestic commercial transformer oils from various origins (Table).

The additives disalicylideneethylenediamine (a deactivator) and anthranilic acid (a passivator) were studied, along with combinations of these additives with one another and with antioxidants: phenyl-B-naphthylamine and 2,6-di-tert-butyl-4-methylphenol (Ionol).

The effectiveness of these additives was rated by laboratory methods, which simulate the most important conditions to which the oil is subjected in transformers. One of the methods consists in oxidizing the oil for 44 hours with oxygen under static

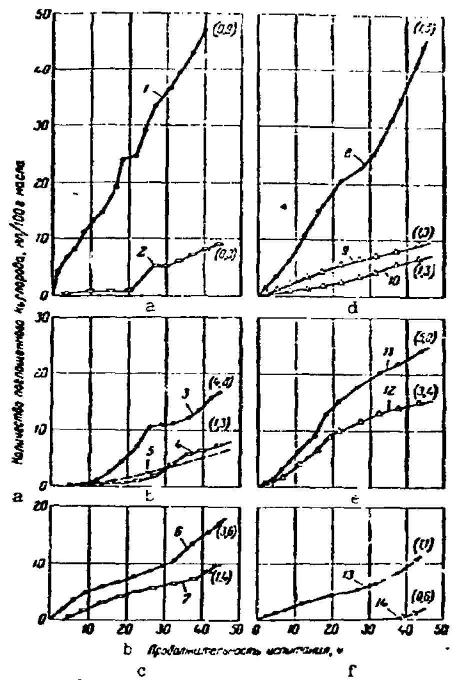

Fig. 1. Kinetic oxygen absorption curves of transformer oils with additives during oxidation in an electric field (a-f): 1) imported oil (GDR) without additive; 2) same oil with 0.05% anthranilic acid; 3) oil from Baku crudes without additive; 4) same oil with 0.05% anthranilic acid; 5) oxidation without copper; 6) oil from Tuymazy crude, hydrofined and contact-rerefined without additive; 7) same oil with 0.05% anthranilic acid; 8) oil from Tuymazy crude, phenol refining, without additive; 9) same oil with 0.05% anthranilic acid and 0.3% Ionol; 10) same oil with 0.05% disalicylideneethylenediamine and 0.3% Ionol; 11) oil from Anastas'yev crude without additive; 12) same oil with 0.5% anthranilic acid; 13) oil from Buzovninsk crude, adsorption refining, [Key cont'd. on page 104]

[Key to Fig. 1, cont'd.] without additive; 14) same oil with 0.05% anthranilic acid. The tan δ values of the oils (at 70°C, in %) after oxidation are given in parentheses. KEY: (a) amount of oxygen absorbed, ml/100 g of oil; (b) test time, hours.

conditions in the presence of catalysts (copper and iron), in an electric field of 49 kV/cm at 100°C. The oxidizability of the oil is evaluated from the rate of oxygen absorption and from the change in the properties of the oil. In another method, the oil is oxidized without an electric field for 1000 hours at ... in the presence of a copper catalyst with air given free access. The change in oxidation rate is observed through the quality indicators of the oil after 240, 480 and 720 hours. Taken together, these laboratory methods yield a preliminary rating of the performance properties of transformer oils with and without additives.

As is now customary in evaluating the quality of transformer oils, the data from the laboratory experiments were compared with results from tests of oil specimens with additive mixes in small bench transformers [5].

It was established by the preliminary experiments that when 0.2% by weight of the antioxidant additive Ionol is introduced into transformer oils (see Table 1), stability is not always improved, especially in the case of the [sic] electrophysical indicators (the tangent of dielectric loss angle tan δ).

The results obtained when deactivating and passivating additives are used are different.

Tests in an electric field indicate (Fig. 1) that on addition of 0.05% of anthranilic acid to the various oils, the oxidation process is retarded appreciably. The kinetic curves of oxygen absorption by the oils with the anthranilic acid additive are smooth and coincide almost perfectly with the oxidation curves of the corresponding oil without the additive or catalyst. The oxidation curves of oils with anthranilic acid characteristically show slow absorption of oxygen at the beginning of oxidation, without the extended induction period that is usually observed in oxidation of oils with inhibiting additives.

Stability of the indicator tan δ, which characterizes the insulating properties of the oils, is highly important for the performance of transformer oils. During oxidation, the tan δ of oils with anthranilic acid increases much more slowly than for oils without this additive.

In analyzing the results of 1000-hour oil-oxidation tests (Fig. 2), we note that the stabilizing action of anthranilic acid manifests in the oxidation of oils from various origins and containing various amounts of carbon in aromatic rings (% ...).

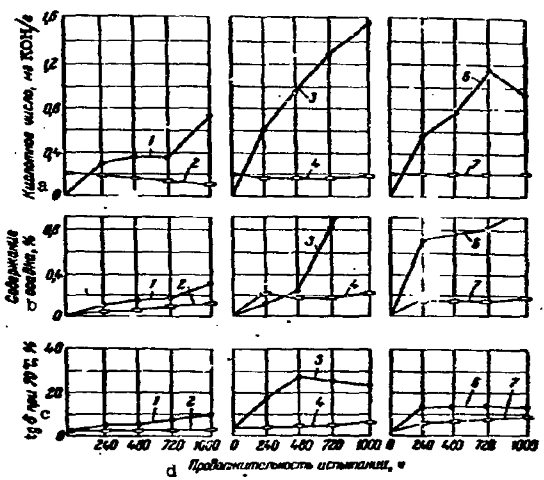

Fig. 2. Kinetic curves of indicator changes during oxidation (1000 h) of transformer oils with 0.05% anthranilic acid (for legend see Fig. 1).
KEY: (a) acid number, mg of KOH/g; (b) sediment content, %; (c) tan δ at 70°C, %; (d) test time, hours.

Oils with anthranilic acid show a typical slow increase in tan δ during oxidation. The sediment-accumulation curves have small slopes, the original color of the oil changes insignificantly, and in most cases the corrosive aggressiveness of the oil with respect to copper and the contact resistance of the copper plates are reduced substantially. In contrast to inhibited oxidation, the kinetic curves reflecting the change in quantity of acids are smooth in the case of oils with anthranilic acid, with the amount of acids decreasing during oxidation. The latter is associated with depletion of the additive, which is acidic in nature.

During long-term aging of the oils, the passivating film formed on the copper surface disintegrates as the passivator is used up and oxidation products act, and further oxidation of the oil proceeds as though there were no additive present in it. This effect is particularly distinct in oxidation of oils with relatively small natural-inhibitor contents. To protect the adsorbed layer from attack by oxidation products and preserve it for a long time, an antioxidant additive is introduced into

the oil together with the passivator. Then, to the extent that copper does not manifest its catalytic activity, inhibitor consumption decreases and the oil becomes more stable.

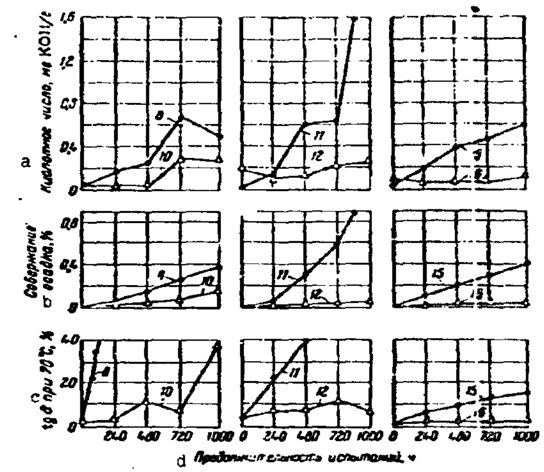

Fig. 3. Kinetic curves of indicator change during oxidation (1000 h) of transformer oils with additive mixes. 15) oil from Emba crudes without additives; 16) same with 0.02 [sic] anthranilic acid and 0.05% disalicylideneethylenediamine (see Fig. 1 for other identifications).
KEY: (a) acid number; mg of KOH/g; (b) sediment content, %; (c) tan δ at 70°C, %; (d) test time, hours.

It was shown for the example of oils made from Anastas[illegible] and Buznovninsk crudes (Fig. 3) that oxidation of the oils is inhibited sharply by use of a mixture consisting of 0.005% anthranilic acid and 0.1% phenylnaphthylamine.

It was established by the foregoing experiments that this effect is not observed when each of these additives is used alone. When the two additives are used, the tangent of dielectric loss angle is stable even when separate introduction of 0.7% by weight of Ionol or 0.05% by weight of anthranilic acid does not produce the required effect.

Thus, when oil from Tuymazy crude is oxidized with each of the above additives, tan δ has already increased by 100% after 240-480 hours. On the other hand, when a mix consisting of 0.02% disalicylideneethylenediamine and 0.2% Ionol is introduced into the oil, its tan δ has increased only 43% after 1000 h of oxidation.

The stability of oil made from Emba crudes is improved substantially on addition of 0.05% disalicylideneethylenediamine and 0.02% anthranilic acid — something that could not be accomplished by use of a single additive. In this case, the action of the deactivator on the homogeneous catalyst — the dissolved copper — and that of the passivator on the heterogeneous catalyst — the metallic copper — are manifested simultaneously. Since there is an amino group in the anthranilic acid molecule, this passivator also has a weak inhibiting effect.

It should be noted that when the oil contains relatively large amounts of natural inhibitors, stability is improved only insignificantly by introducing an inhibiting additive together with the passivator (anthranilic acid).

Earlier experiments conducted with a hydrofined oil made from Tuymazy crude confirm this. The results of laboratory tests to evaluate the effectiveness of additive combinations were confirmed in the bench tests with small transformers.

Additive mixes consisting of 0.05% anthranilic acid with 0.2% phenylnaphthylamine and 0.02% anthranilic acid with 0.05% disalicylideneethylenediamine improve the stability of oils made from Anastas'yev and Emba crudes. In particular, corrosion of copper is reduced substantially and destruction of specimens of solid insulating materials placed in the oil is retarded by a factor of 2-3.

A mix consisting of 0.05% anthranilic acid and 0.2% Ionol improves the stability of phenol-refined Tuymazy oil more effectively than a composition consisting of 0.05% disalicylideneethylenediamine and 0.2% Ionol. The difference in the effects of the two mixes is most noticeable in the relative amount of solid-insulation wear.

CONCLUSIONS

It has been shown that use of a passivating additive, anthranilic acid (0.05% by weight), in pure form and especially in mixes with antioxidant additives (Ionol, phenyl-α naphthylamine) ensures better stability (especially electrophysical) of commercial transformer oils of various origins and chemical compositions than when only the inhibiting additive is used.

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Symbol List

Manuscript page	Symbol		English Equivalent
102	A	A	aromatics
102	H	N	naphthenics

INVESTIGATION OF ADDITIVES AND ADDITIVE OILS BY A POTENTIOMETRIC METHOD

V.S. Luneva and L.N. Burdenyuk

The advantages of using a potentiometric method to evaluate the acid-base properties of additives and oils containing additives and their wearability under the operating conditions of various types of engines have been confirmed by a number of research studies [1, 2].

ALKALINITY OF ADDITIVES

The alkalinity of an additive is governed by the presence of free and bound alkaline components [3,4]. Additive alkalinities were determined by potentiometric titration using antimony and calomel electrodes; 1 g of additive dissolved in 40 ml of an alcohol-benzol mixture (1:2) was decomposed by a 0.1n alcoholic solution of HCl. The titration curves appear in Figs. 1-6. As we see, the nature of the curves changes in accordance with the type of the salts decomposed: alkylsalicylate (ASK, MASK), alkylphenol (VNII NP-370, TsIATIM-339, VNII NP-370p), sulfonate (PMS'Ya), thiophosphate (DF-11, Santolube 493), etc. The length of the horizontal segment on the titration curve is proportional to the concentration of the salts decomposed during titration of equal weights. Additives containing the cations Ca, Ba, and Mg have an alkaline reaction (pE = 8-13 or ΔpH = 1-6).

Alkylsalicylate (ASK, MASK) and sulfonate (PMS'Ya) additives are characterized by free alkalinity (see initial segments of curves in Figs. 1-6). The alkylphenol additives (TsIATIM-339, VNII NP-370p, etc.) do not contain free alkalies.

The titration curves indicate that most of the additives are totally decomposed at electromotive forces [emf] (ЭДС) of about 100-120 mV (pH = 2).

It is known that the total alkalinity [T.A.] (О.Щ.) of most additives is equivalent to the content of metal present in them. This is confirmed by the data given in Table 1.

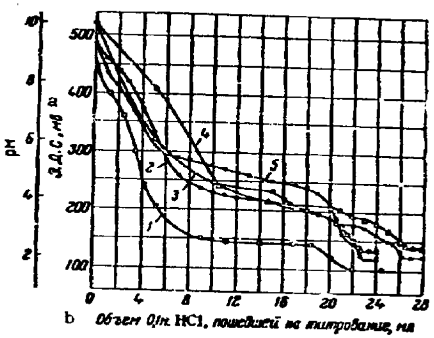


Fig. 1. Potentiometric titration curves of MASK additive. 1-5) various batches.
KEY: (a) emf, mV; (b) volume of 0.1n HCl used in titration, ml.

However, this equivalence is not observed in the PMS'Ya and VNII NP-370 additives, so that alkalinity should generally be used to determine the effective content of metal, i.e., the content equivalent to that part of the additive that participates in neutralization of fuel combustion products. In introducing additive mixtures into the oil, it must be remembered that the sulfate ash content of PMS'Ya additive exceeds its total alkalinity by a factor of almost 1.5. PMS'Ya additives have different alkalinities at a given ash content (see Table 1). The increase in the ash content of the oil as the additives are depleted is one of the causes of increased wear, while inadequate alkalinity is among the causes of increased sludging. Hence it is necessary to check alkalinity and ash content in both the original additive oils and oils in use in engines.

INVESTIGATION OF ADDITIVES OF THE ZINC DITHIOPHOSPHATE TYPE

Owing to the amphoteric properties of zinc, its salts are decomposed by both acids and alkalies. Figure 4 presents potentiometric titration curves of zinc dialkyl- and diaryldithiophosphates, showing that the potential jump in acid titration

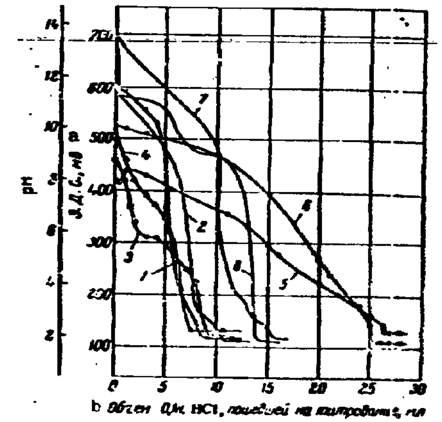


Fig. 2. Potentiometric titration curves of alkylphenol additives. 1,2) TsIATIM-339; 3,4) VNII NP-370; 5,6) VNII NP-370p; 7) VNII NP-380; 8) APB.
KEY: (a) emf, mV; (b) volume of 0.1n HCl used in titration, ml.

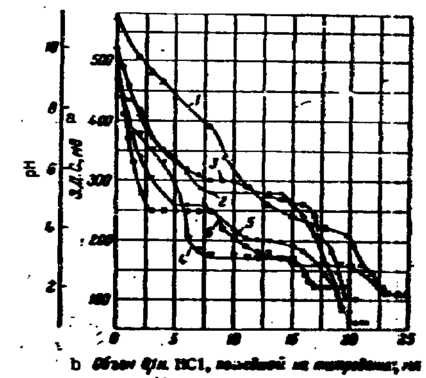


Fig. 3. Potentiometric titration curves of PMS'Ya additive. 1-6) various batches.
KEY: (a) emf, mV; (b) volume of 0.1n HCl used in titration, ml.

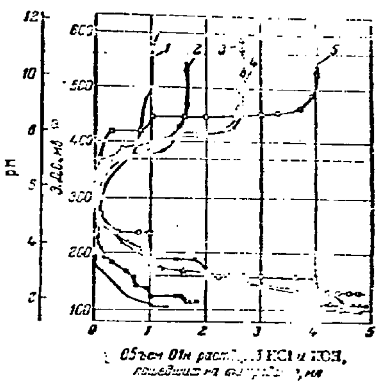


Fig. 4. Curves of potentiometric titration of zinc thiophosphates with alkali and acid. 1) VNII-NP-354; 2) DF-11; 3) Lubrisol 1360; 4) Santolube 394; 5) Ecolube 99.
KEY: (a) emf, mV; (b) volume of 0.1N HCl or KOH used in titration, ml.

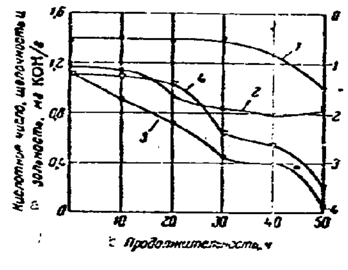


Fig. 5. Wearability of AS-9.5 oil with 0.6% Orobis-Jloa 267 on IT9-2 bench installation. 1) sulfate ash content; 2) total acid number; 3) total alkalinity; 4) reaction.
KEY: (a) acid number, alkalinity, and ash content, mg of KOH/g; (b) time, hours.

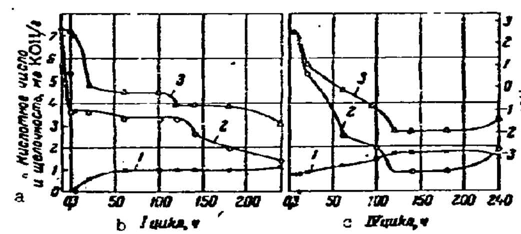


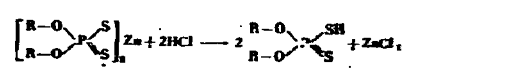
Fig. 6. Wearability of M14-V oil (DS-14 with 3% TsIATIM-339, 2% PMS'Ya, and 0.003% PMS-200A) in SMD-14 engine during cycles I and IV. 1) total acid number; 2) total alkalinity; 3) reaction.
KEY: (a) acid number and alkalinity, mg of KOH/g; (b) cycle I, hours; (c) cycle IV, hours.

Table 1. Results of Potentiometric Determination of Reaction, Alkalinity, Effective Metal and Sulfate-Ash Contents in Additives

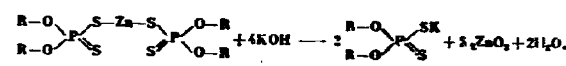
	a Присадка	b Реакция ±ΔpH	c Щелочность, мг KOH/г	d Содержание, %: e кальция	d: f золы сульфатной (Б)	g Зола сульфатная* (А): %	g: h мг KOH/г	i Разность А−Б: %	i: мг KOH/г
j	АСК-5в	3.2	62.8	2.24	7.60	7.59	62.[illegible]	[illegible]	[illegible]
k	АСК-7в	3.8	67.5	2.41	8.20	8.20	67.50	0.0	0.0
l	МАСК	1.6	150	5.40	18.15	18.[illegible]	148.3	[illegible]	1.7
l	МАСК	2.3	135.8	4.57	15.34	16.24	134.6	1.0	7.4
m	ПМСЯ	2.0	125.4	4.46	15.30	23.60	150.0	[illegible]	[illegible]
m	ПМСЯ	4.5	134.5	4.76	16.27	19.90	[illegible]	[illegible]	[illegible]
n	ВНИИ НП-370п	0.8	120.0	3.00	16.94	16.98	139.9	[illegible]	[illegible]
n	ВНИИ НП-370п	2.7	125.5	6.58	23.65	23.90	150.0	[illegible]	[illegible]
o	ВНИИ НП-370	3.5	[illegible]	1.41	4.25	7.60	63.0	[illegible]	[illegible]
p	ЦИАТИМ-339	5.2	[illegible]	5.09**	8.80	5.60	41.2	1.2	1.0
p	ЦИАТИМ-339	4.2	[illegible]	5.68**	9.80	9.70	57.0	0.1	[illegible]
q	АФБ	6.3	78.26	9.54**	15.78	15.78	78.26	0.0	0.0
r	МСЖК	1.3	165.2	3.28***	17.67	17.00	163.3	[illegible]	[illegible]

*Determined by turning the additive with sulfuric acid.
**Barium.
***Magnesium.
KEY: (a) additive; (b) reaction, ±ΔpH; (c) alkalinity, mg of KOH/g; (d) content, %; (e) calcium; (f) sulfate ash (B); (g) sulfate ash* (A); (h) mg of KOH/g; (i) difference A − B; (j) ASK-8v; (k) ASK-7v; (l) MASK; (m) PMS'Ya; (n) VNII NP-370p; (o) VNII NP-370; (p) TsIATIM-339; (q) AFB; (r) MSZhK.

is less distinct because of the accumulation of thiophosphoric (in addition to hydrochloric) acid in the additive solution. Decomposition takes place by the reaction



The potential jump is sharper on decomposition of the additives by alkali according to the reaction



Two potential jumps can be brought out in titration of small weights (0.1g) (see Fig. 4); they correspond to decomposition of the salts with formation of thiophosphoric acid and potassium thiophosphate or decomposition of salts with various alcoholic radicals.

Total decomposition of zinc dithiophosphates by alkali is accompanied by a potential jump in the 460-600 mV range (pH = 9-12). The total acid number [T.A.N.] (О.К.Ч.) of the additive is determined from the amount of alkali used in titrating to 520 mV (pH = 10).

The total acid number is converted by the formulas given below to the zinc and phosphorus contents.

$$\text{О.К.Ч.} = \frac{V_1 - V_2 T}{l} \text{ mg of KOH/g}$$

where V_1 is the amount of 0.1n alcoholic KOH solution used in titrating the additive solution to pH = 10 (520 mV), in ml; V_2 is the amount of the same solution used in titrating the solvent (blank experiment) to pH = 10 (520 mV), in ml; T is the titer of the 0.1n KOH solution, in g/ml; l is the weight of the additive sample, g.

The zinc content is

$$x_1 = \frac{\text{О.К.Ч.} \cdot 0.583}{10} \ \%$$

The phosphorus content is

$$x_2 = \frac{\text{О.К.Ч.} \cdot 0.55}{10} \ \%$$

where 0.583 is a coefficient obtained by dividing the atomic weight of zinc by the molecular weight of KOH; 0.55 is a coefficient obtained by dividing the atomic weight of phosphorus by the molecular weight of KOH; 10 is the coefficient for conversion to percent.

Example. For the Santolube 493 additive:

$$\text{О.К.Ч.} = \frac{(29.3 - 0.1)\,5.19}{1} = 151{,}5 \text{ mg of KOH/g}$$

$$x_1 = \frac{151.5 \cdot 32.69}{56.1 \cdot 10} = \frac{151.5 \cdot 0.583}{10} = 8{,}83\%$$

$$x_2 = \frac{151.5 \cdot 30.96}{56.1 \cdot 10} = \frac{151.5 \cdot 0.55}{10} = 8{,}33\%$$

The advantages of the potentiometric method of determining zinc and phosphorus in the additives over the spectral, gravimetric, and calorimetric methods [7, 8] include the simplicity and speed of the analysis and the absence of turning or oxidation and precipitation losses; the time for a determination (1.5-2 hours) is smaller by a factor of more than 20 than in other presently known methods [7, 8, 9].

In Table 2, the results of potentiometric determination of zinc and phosphorus in the additives are compared with the results obtained by other methods. Table 3 presents the results of potentiometric determination of reaction, total acid number, and phosphorus and zinc contents; it shows that all of the thiophosphoric additives analyzed have an acid reaction due to the presence of the strong thiophosphate anion. The phosphorus content of the imported additives is considerably higher than that in the Soviet additives. The error of the results of determination varies: ± 0.02% for the foreign additives and 0.0? to 0.5% for the domestic ones; the spread of the determinations ranges from 2.4 to 9%. The potentiometric method can be used to establish the presence of small amounts of zinc and phosphorus (tenths and hundredths of a percent).

The presence of sulfur in these additives does not interfere with potentiometric determination of zinc and phosphorus; here the emf values measured with the antimony electrode are not distorted.

On the whole, the above justifies recommending alkali potentiometric titration of zinc dithiophosphate for quantitative determination of phosphorus and zinc in the additives. The method can be used in research studies and to control additive quality.

Potentiometric investigation of various types of additives enables us to compute coefficients for conversion from total alkalinity to effective content of metal and sulfate ash, as

Table 2. Results of Quantitative Determination of Phosphorus and Zinc in Additives by Various Methods

a Образец	b Содержание, %: P, c	P, d (ГОСТ 9436-63)	Zn, c	Zn, e (ГОСТ 8899-61)
g Сантолюб-493	8.32	8.1	8.50	8.7
h Оробис-Олоа-267	8.41	8.3	8.50	8.7
i Любризол-1360	7.65	7.85	8.08	—
j ДФ-11	4.9.	4.5*	5.31	5.28
k ВНИИ НП-354	2.75	2.5	2.67	2.5
l ЛАНИ	3.76	3.69*	3.97	3.7
m Масло, содержащее опытный образец дитиофосфата цинка	0.16	0.15—0.18	0.17	0.15—0.18

*Determined calorimetrically (GOST [All-Union State Standard] 9827-61).
KEY: (a) specimen; (b) content, %; (c) potentiometric method; (d) spectral method (GOST 9436-63); (e) spectral or gravimetric method (GOST 8899-61); (g) Santolube 493; (h) Orobis-Oloa-267; (i) Lubrisol 1360; (j) DF-11; (k) VNII NP-354; (m) oil containing test specimen of zinc dithiophosphate.

Table 3. Results of Determination of Reaction, Total Acid Number, and Phosphorus and Zinc Contents in Metal-Dithiophosphate-Type Additives by Potentiometric Method

a Образцы	b Навеска, г	c Реакция ±ΔpH	d Общее кислотное число, мг KOH/г	e Содержание, % P	Zn
f Сантолюб-493	1	−1.6	151.5	8.33	8.91
	0.1	−1.5	151.5	8.31	8.80
g Оробис-Олоа-267	1	−1.1	152.7	8.41	8.86
	0.1	−1.2	153.2	8.42	8.90
h Лубризол-1360	1	−2.1	130	7.65	8.09
	0.1	−0.8	130	7.65	8.08
i Эколюб-99	1	−1.9	217.8	11.98	12.58
	0.1	−1.6	217.9	11.98	12.59
j ЛАНИ					
k ДФ-11					
l образец 1	1	−3.6	83.2	3.76	3.97
l образец 2	1	−2.2	89.9	4.96	5.31
m ВНИИ НП-354	0.1	−1.7	108	5.82	6.18
	0.1	−3.7	48.5	2.75	2.67
n Масло, содержащее опытный образец дитиофосфата цинка					
l образец 1	1	−3.3	1.38	0.07	0.08
l образец 2	1	−1.9	2.90	0.16	0.17

KEY: (a) specimen; (b) weight taken, g; (c) reaction; (d) Total acid number, mg of KOH/g; (e) content, %; (f) Santolube 493; (g) Orobis-Oloa-267; (h) Lubrisol 1360; (i) Ecolube 99; (j) LANI; (k) DF-11; (l) specimen ...; (m) VNII NP-354; (n) oil containing experimental specimen of zinc dithiophosphate.

Table 4. Conversion Factors K

a Присадки	b Определяемые элементы	c d металла	c e сульфатной золы	f 1	f 2	g 1	g 2	h Zn	h P
i АСК, МАСК, ПМСЯ, ВНИИ НП-370, ВНИИ НП-370п	j Кальций	0.357	1.21	2.80	0.824	0.293	3.335	—	—
k ВНИИ НП-350, ЦИАТИМ-339, АФБ	l Барий	1.22	2.08	0.817	0.480	0.558	1.69	—	—
m Эколюб-856, МСЖК	n Магний	0.217	1.07	4.78	0.932	0.202	4.95	—	—
o Сантолюб-493, Оробис-Олоа-267, ДФ-11	p Цинк	0.583	1.44	1.71	0.605	0.405	2.47	0.583	—
	q Фосфор	—	—	—	—	—	—	—	0.55

*Working formula: $Me(MeSO_4) = T.A. \cdot K:10$, % (here Me is the metal content and $MeSO_4$ is the sulfate-ash content).
**Working formula: $T.A. = Me(MeSO_4)K \cdot 10$, mg of KOH/g.
***Working formula: $Zn(P) = (T.A.N. \cdot K)/10$, %.
KEY: (a) additive; (b) element determined; (c) from total alkalinity to content,* %; [cont'd on page 118]

[Key to Table 4, cont'd.] (d) of metal; (e) of sulfate ash; (f) from metal content (1) and sulfate ash (2) to total alkalinity**; (g) from ash content to metal content (1) and back (2); (h) from total acidity to content of,*** %; (i) ASK, MASK, PMS'Ya, VNII NP-370, VNII NP-370p; (j) calcium; (k) VNII NP-350, TsIATIM-339, AFB; (l) barium; (m) Ecolube 856, MSZhK [synthetic fatty acid magnesium salt]; (n) magnesium; (o) Santolube 493, Orobis-Oloa-267, DF-11; (p) zinc; (q) phosphorus.

well as for conversion from total acidity of the zinc thiophosphates to their contents of zinc and phosphorus (Table 4).

ON THE QUESTION OF OIL SERVICE LIFE IN ENGINES

The wearability of oils with additives is the basic question to be resolved in establishing oil-change intervals for engines, and many investigators are working on it [10-13].

At one time [1], the question was raised as to the use of the potentiometric method to rate the acid-base properties of additive oils and their wearability in various types of engines.

The additive consumption computed from the change in oil ash content does not agree with the actual consumption, as shown in Figs. 5 and 7 and in Table 5.

As we see, alkalinity does not vary in proportion to ash content during depletion in engines. Acidity varies as a function of additive type, and, as a rule, the reaction (ΔpH) changes from alkaline to acid or almost neutral (see Figs. 5-7).

Then, as we know, the viscosity of the oil and its coking capacity increase (Fig. 7b).

When the engines are operated under the same conditions (for example, the GAZ-51), equal quantities of the alkaline components are depleted, despite the difference in compositions (see Table 5). The amounts of sludge and wear are somewhat smaller at higher oil alkalinity.

Without additives, DS-14 oil services the YaAZ-204 engine for no more than 20 hours, and with additives for 85 hours; heavy sludging appears at alkalinities of 0.5 mg of KOH/g or less.

DS-14 oil with 3% TsIATIM-339, 2% PMS'Ya and 0.005% PMS-200A provides for normal operation of the SMD-14 engine for 800 hours (see Fig. 6). Sludge appears after 500 hours in the Kolomna plant's D-2 engine, with alkalinity not exceeding 0.4 mg of KOH/g. The alkalinities of the original oils were not the same (the oil used in the SMD-14 engine was more alkaline).

Oil M-20B (MS-20 with 2.5% TsIATIM-339, 1.5% PMS'Ya and 0.005% PMS-200A) works for 1300 hours in the M-7 engine 24

Table 5. Physicochemical and Motor Properties of Additive Oil Before and After Use in GAZ-51 Engine

a Масло с присадками	b Кислотно-основные свойства: ±ΔpH	c	d	e Срабатываемость: ±ΔpH	c	d	f Моторная оценка: g	h	i	j	k	l Содержание, %: m	n
o М-10Б (АС-9,5+ +1,5 Монто-613+ +0,7% Санто-люб-493):													
p исходное	1.3	3.1	0.4								10.7	0.47	0.38
q после 600 ч работы	−3.8	0.5	1.6	−5.1	−2.6	1.2	4.7	25	0.12	65	12.6	1.10	0.25
r М-10Б (АС-9,5+ +3,5% АСК+ 1,2% ДФ-11+ +0,003% ПМС-200А):													
p исходное	1.0	4.2	1.1								9.8	0.73	0.33
q после 600 ч работы		1.6	4.4	−3.7	−2.8	3.3	2.13	15	0.04	47	10.7	1.25	0.27
s М-10А (АС-9,5+ +1,5% АСК+ 1,2% ДФ-11+ +0,003% ПМС-200А):													
p исходное	0.7	3.1	0.8								9.7	0.32	0.22
q после 600 ч работы	−2.3	0.6	2.4	−3.0	−2.5	1.6	3.5	18	0.05	39	10.2	0.53	0.10

KEY: (a) oil with additives; (b) acid-base properties; (c) total alkalinity, mg of KOH/g; (d) total acid number, mg of KOH/g; (e) wearability; (f) motor rating; (g) amount of carbon on rings and piston, g; (h) cylinder wear (by method of lunes), μ; (i) weight loss of first piston ring, g; (j) oil burnoff, g/h; (k) viscosity at 100°C, cst; (l) content, %; (m) coke; (n) ash; (o) M-10B (AS-9.5 + 1.5 Monto 613 + 0.7% Santolube 493; (p) original; (q) after 600 hours of use; (r) M-10B (AS-9.5 + 3.5% ASK + 1.2% DF-11 + 0.003% PMS-200A); (s) M-10A (AS-0.5 + 1.5% ASK + 1.2% DF-11 + 0.003% PMS-200A).

stages, each lasting 50 hours) instead of the specified 100 hours. The engine was in satisfactory condition.

We see from the data obtained (Fig. 5-7) that the alkalinity decrease depends not only on the duration of engine running, but also on running conditions.

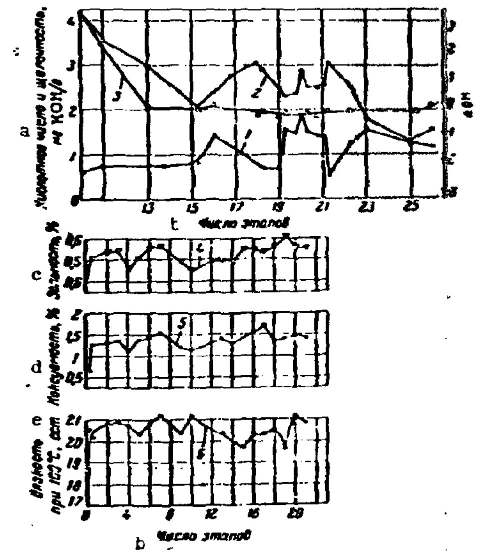


Fig. 7. Wearability of M-20V oil (MS-20 with 2.5% TsIATIM-339, 15% PMS'Ya and 0.005% PMS-200A) in M-7 engine. 1) total acid number; 2) total alkalinity; 3) reaction; 4) ash; 5) coking capacity; 6) viscosity. KEY: (a) acid number and alkalinity, mg of KOH/g; (b) number of stages; (c) ash, %; (d) coking capacity, %; (e) viscosity at 100°C, cst.

CONCLUSIONS

1. The possibility and expediency of direct titration of additives to 120-100 mV (pH = 2) to determine total alkalinity and their effective metal and sulfate-ash content (the latter for those additives in which alkalinity is equivalent to ash) were demonstrated.

2. The sulfonate additives (PMS'Ya) differ sharply from one another as regards total alkalinity, and hence in effective calcium content; y have varying contents of nondecomposible

compounds, ranging up to 9% (converted to calcium sulfate).

3. The zinc thiophosphates that were analyzed had an acid reaction; their acid numbers were proportional to phosphorus and zinc content; the imported additives contained substantially more phosphorus and zinc than the Soviet ones. A fundamentally new method was proposed for quantitative determination of phosphorus and zinc by titrating zinc dithiophosphate to the potential jump or, in the general case, to 520 mV (pH = 10). The error of the method is 0.02 to 0.25%, its reproducibility from ±2.4 to ±9%, and the time required for the determinations 1.5-2 hours.

4. A study of the acid-base properties of additive oils in various types of engines brought out a disproportionality between the depletion of the alkaline component and the accumulation of acidic compounds; alkalinity does not vary in proportion to ash content. It was established that in engines operated under uniform conditions (GAZ-51) but on oils with different additive mixes, the alkalinity reserve varies in about the same way. A relation was detected between alkalinity change and the cleanliness and wear of certain engines.

5. The expediency of using the potentiometric method of wearability rating for additive oils to arrive at change intervals for these oils in various types of engines was demonstrated.

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